2009

Elementary Teachers Attitudes Towards Science and the Teaching of Science and Technology

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ELEMENTARY TEACHERS' ATTITUDES toward SCIENCE and the TEACHING of SCIENCE and TECHNOLOGY

by
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A Thesis
Submitted to the Faculty of Graduate Studies
through the Faculty of Education
in Partial Fulfillment of the Requirements for the
Degree of Master of Education at the
University of Windsor

Windsor, Ontario, Canada

2009

Approval Page

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ABSTRACT

Quantitative and qualitative methods were used to examine the relationship between teachers' attitudes, beliefs, and their perceptions of students' attitudes about Science and Technology (S&T), gender differences in students' patterns of S&T learning, and teachers' perceptions of scientists and S&T. A sample of 50 grade 4 to 8 teachers completed an original questionnaire and 10 of those participants were subsequently interviewed. The quantitative results suggested that teachers that perceive their students' attitudes as positive and hold no prejudices about scientists or negative opinions about S&T tend to perceive no gender differences in students' attitudes. The qualitative analyses concerning teachers' beliefs about scientists/S&T principally confirmed all quantitative findings. The further exploration of the relationships between teachers' attitudes and their beliefs concerning scientists/S&T, however, indicated that the results are two-edged.

ACKNOWLEDGEMENTS

Many individuals provided invaluable guidance during this study, and I am very grateful for their support. I sincerely thank my thesis supervisor, Dr. Anthony N. Ezeife for his guidance, patience, and support throughout the entire process. His valuable suggestions and sharp editing skills were indispensable. I also would like to thank Dr. Geri Salinitri, my second reader, sincerely for her advice and encouragement throughout my study that helped me to move forward with my thesis. Further, I would like to thank Dr. Lynda Corkum for agreeing to be my external reader and for her interest in this study. Her gracious support and encouragement is very much appreciated. My special thanks go to Dr. S. Nombuso Dlamini who awakened in me the interest in, and love for, doing research in education. Her ceaseless encouragement, amazing help, gracious support, and valuable advice led me through the master's program and helped me tremendously to complete my thesis. I would further like to acknowledge all the principals and teachers, particularly those who took the time to meet with me in person for a one-on-one interviews, and who made this study possible. Further, my husband deserves innumerable thanks for his ever-present encouragement, understanding, and love. Lastly, I would like to thank our dog that made sure that I take breaks from writing and get some fresh air while going for a walk with him.

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CHAPTER I

INTRODUCTION

A. Statement of the Problem

Elementary school teachers have a vast responsibility to introduce students to Science and Technology (S&T) and to motivate them to learn subjects related to S&T. Ideally, elementary school teachers create the academic and emotional/mental basis for their students' S&T comprehension and encourage them not only to continue the study of those subjects but to become life-long learners in those areas. If more students take S&T courses in high school then there is the likelihood that a greater number of students will enrol in science-related courses in higher institutions of learning. This will result in preventing a shortage of workers and academics in S&T that is predicted globally (Angell, Guttersrud, Henriksen, & Isnes, 2004). The number of female engineers, computer scientists, and physicists that work in industry and the academe is decreasing, in contrary to the overall increasing number of women in the workforce (Statistics Canada, 2006). One way that can help with this predicament is enhancing girls' attitudes toward S&T and encouraging them to study S&T in elementary school, which is to a major part the responsibility of their teachers. As has been shown in regards to early mathematics teaching, which forms the base to the learning of S&T, an elementary school teacher who does not enjoy or is anxious about teaching mathematics will most likely transfer her/his negative attitudes to her/his students (Clements, Sarama, & DiBiase, 2004; National Research Council, 1989).

The purpose of this study is to investigate the attitudes grade 4 to 8 elementary school teachers adopt toward the teaching of S&T and how this disposition is shaped by their perceptions. That is, to investigate how their attitudes are influenced by their perceptions of students' S&T learning, their image of the scientist, and their views about the nature of science. Furthermore, one of the objectives is to explore whether those educators' beliefs and insights of people who work in scientific/technological fields affect grade 4 to 8 educators' teaching, particularly in regards to the gender of their students.

Research in this domain is crucial for several reasons. First, there is a scarcity of research about grade 4 to 8 teachers' attitudes to S&T as taught in elementary school as well as practiced outside the school environment. Secondly, there is need to investigate elementary teachers' beliefs regarding the nature of science as well as to explore their images of the scientist, which is particularly important in order to detect possible sources of biased teaching practices. Thirdly, there is a necessity to enhance students' interest in S&T so as to increase the number of students, particularly female students, aiming for an education and career in related fields. Fourth, there is hope that grade 4 to 8 teachers will become aware of their attitudes toward the teaching of S&T along with gaining increased awareness of possible inequities in their S&T classroom. And finally, research in this area is of importance in order to agitate for professional development programs and other services that would help in-service grade 4 to 8 teachers in their S&T teaching.

B. Definition of Terms

Attitude: in psychology, attitude is a feeling or emotion toward a fact or state. A model developed by Fishbein and Ajzen (1980) describes an individual's attitude toward any object as a function of the individual's beliefs about the object as well as the implicit evaluative responses associated with those beliefs. Attitudes are expected to change as a function of experience, in contrast to personality.

Attitudes toward S&T: the term derived from the definition of ‘attitudes toward science’ proposed by Osborne, Simon, and Collins (2003) and has been expanded for the purpose of this study to include technology. Therefore, attitudes toward S&T are the feelings, beliefs and values held about an object that may be the endeavour of S&T, the school subject S&T, as well as the impact of S&T on society or scientists themselves. These attitudes are shaped by several sub-constructs, all of which contribute in varying proportions toward an individual’s attitudes to S&T, and can be expressed consciously or unconsciously.

Comfort level/zone: “…is a behavioural state within which a person operates in an anxiety-neutral condition, using a limited set of behaviours to deliver a steady level of performance, usually without a sense of risk” (White, 2008, p. 3).

Confidence: is generally described as a state of being certain that a chosen course of action is the best or most effective given the circumstances (The Oxford English Dictionary, 1989).

Gender: is based on the gender identity of an individual. According to Yoder (2007), it is a person’s own sense of identification as distinguished from actual biological sex. The term “gender” as used in this study refers to specifically social differences between two or more sexes, known as gender roles that are socially constructed.

Gender bias: adapted from the term “bias”. It is defined as the inclination or prejudice for or against one person or group, especially in a way considered to be unfair (The Oxford English Dictionary, 2005). Gender bias describes a judgment or action that is influenced by a prejudged perspective of gender differences (see gender definition above). Teachers that exhibit a tendency to favour a certain set of values regarding gender are, therefore, inclined to an uneven dispensation of judgment.

Perceptions of Students' Attitudes: The term derived from the definition of 'perceptions' in general as given in the Encyclopaedia Britannica Online (2009). "Perceptions of Students' Attitudes" are defined for the purpose of this study as teachers' perceptions of their students' attitudes toward S&T learning. It is assumed that these perceptions are based on teachers' observations of students' behaviours in the S&T classroom, which are most likely influenced by teachers' beliefs and opinions about students' attitudes. The existence of a correlation between attitude and behaviour is widely accepted in social psychology (Ajzen, 1988; Fishbein & Ajzen, 1975).

Rotary Teacher: is a teacher who 'rotates' between different classes and grades to teach one particular school subject, according to study participants (oral communication). Rotary teachers are commonly specialty teachers (see below) or educators who are exceptionally knowledgeable in a certain area and very skilled in teaching it due to their education and/or job-related experiences.

S&T: is the school subject with the same name as described in the Ontario Curriculum Grade 1-8 Science and Technology (1998). The Ontario Ministry of Education and Training does not distinguish between the school subjects Science and Technology and incorporates in its guidelines the teaching of knowledge from all scientific and technological disciplines. Further, S&T as used in this study includes all aspects of scientific and technological fields.

Scientist: is a person with expert knowledge of science; a person using scientific methods (The Oxford English Dictionary, 1989).

Self-confidence: is having confidence in oneself when considering a capability (The Oxford English Dictionary, 1989). It also relates to self-assuredness not only in one's personal ability but also one's judgment and power. Self-confidence is often equivalent to confidence (The Oxford English Dictionary, 1989).

Self-efficacy: Each individual has, according to Bandura (1981) a sense of self-efficacy, which is "concerned with judgements about how well one can organize and execute courses of action required to deal with prospective situations that contain many ambiguous, unpredictable, and often stressful, elements" (pp. 200–201). Self-efficacy is an accurate predictor of performance—people with low self-efficacy about an activity will tend to avoid that activity, whereas people with high self-efficacy will make vigorous and persistent efforts and will therefore be more likely to complete the task successfully. Bandura (1977) also identified two critical components of self-efficacy; 'efficacy expectations' are beliefs in one's ability to successfully execute the behaviour whereas 'response-outcome expectancies' are beliefs that their actions will produce the desired outcome. Self-efficacy is a construct of both of these beliefs that work together to determine behaviour. Bandura (1981) also emphasized that self-efficacy is highly context-dependent, so a person may have a high self-efficacy with respect to one task but a low self-efficacy with respect to another task.

Self-esteem: is the confidence in one's own worth or abilities (The Oxford Dictionary of English, 2005). In order to maintain a positive sense of self-esteem that derives from competence-related beliefs and values, a person might lower the value s/he attaches to difficult activities (Eccles & Wigfield, 2002). Although Eccles and Wigfield (2002) worked with students, their general findings can, for the purpose of this study, be adapted to teachers. It is, therefore, assumed that a teacher's self-esteem most likely influences her/his attitude and, consequently, may be reflected in her/his behaviour in the S&T classroom.

Speciality Science Teacher: is a teacher who is specialized in teaching S&T due to her/his educational background (oral communication with school principals). Most elementary schools with large student populations in the region of this study have speciality science teachers who teach S&T in several grades, mainly grades 7 and 8. In elementary schools without specialty science staff, every teacher teaches S&T in her/his own class (oral communication).

C. Research Questions and Hypotheses

I. Key concepts related to teachers' attitudes toward S&T teaching

1. Teachers' confidence in S&T teaching
2. Teachers' educational background/preparedness to teach S&T
3. Teachers' experiences (years of general teaching and S&T teaching)
4. Teachers' perceptions of students' S&T learning
5. Teachers' perceptions of gender differences in students' S&T learning
6. Teachers' perceptions of the nature of S&T
7. Teachers' perceptions of scientists/engineers and their work
8. Teachers' perceptions of gender differences in science and engineering fields

II. Research questions

The following research questions guided the investigation:

1. What is the strength of the relationship between teachers’ attitudes toward S&T teaching and their perceptions of students’ attitudes to S&T learning?
2. To what extent do teachers’ attitudes to S&T teaching relate to their comfort level in the S&T classroom?
3. How do teachers’ perceptions of students’ attitudes to S&T learning relate to their perceptions of gender differences in students’ attitudes and are those perceptions related to teachers’ beliefs and opinions of scientists and S&T?

III. Hypotheses based on quantitative data

1. There is no statistically significant relationship between teachers’ attitudes toward S&T teaching and
   a. their science education in high school;
   b. their science education at university or college;
   c. the number of years of overall teaching experience;
   d. the number of years of S&T teaching experience;
   e. their knowledge gained through continued S&T learning.
2. There is no statistically significant relationship between teachers’ attitudes toward S&T teaching and their perception of
   a. students’ S&T learning in general;
   b. gender differences in students’ S&T learning.

3. There is no statistically significant relationship between teachers' attitudes toward S&T teaching and their perceptions of S&T.
4. There is no statistically significant relationship between teachers' attitudes toward S&T teaching and their perceptions of a scientist or an engineer.
5. There is no statistically significant difference between female and male teachers' attitudes toward S&T teaching.
6. There is no statistically significant difference between female and male teachers' attitudes toward S&T teaching and their perceptions of students' S&T learning.
7. There is no statistically significant difference between female and male teachers' attitudes toward S&T teaching and their perceptions of gender differences in students' S&T learning.
8. There is no statistically significant difference between female and male teachers' attitudes toward S&T teaching and their perceptions of scientists and S&T.

CHAPTER II

REVIEW OF THE LITERATURE

This study is an investigation into elementary school teachers' attitudes toward the teaching of S&T and some of the factors that influence their S&T teaching. More specifically, this study seeks to establish whether grade 4 to 8 teachers' attitudes toward S&T teaching is shaped by their knowledge, their experiences, their views about science and the scientist, as well as their perceptions of elementary students' attitudes to the learning of S&T.

This chapter begins with an outline of students' attitudes toward S&T. It continues with a discussion of research that examined teachers' attitudes toward S&T teaching and the causes for it. A review of teachers' images of the scientist and their beliefs concerning the nature of science is discussed. The chapter concludes with a summary of the key issues raised in the literature review.

Students' attitudes toward S&T learning

Young children commonly have a positive attitude toward all school subjects, a natural curiosity about quantitative events and some problem-solving skills when starting school (Ontario Ministry of Education, 2003). This attitude shifts, and students of both genders begin to lose interest particularly in science and academic subjects that require a more advanced knowledge of mathematics toward the end of grade six (Jones, Howe, & Rua, 2000; Simpson & Oliver, 1990). Moreover, a gender gap appears soon after, with more girls than boys disliking science and technology classes in middle school (Catsambis, 1995) and with more girls than boys opting out of science classes in high school (Watt, 2005). This trend continues in some S&T related disciplines such as physics, mathematics, engineering and computer science in higher education with decreasing student enrolments overall and female students in particular (Canadian Association of University Teachers, 2007). Consequently, the number of young people pursuing careers in those fields is not keeping up with the demand in Western industrialized countries (Angell, Guttersrud, Henriksen, & Isnes, 2004). University and college students' indifference to the hard sciences and disciplines requiring an advanced knowledge of mathematics derives from their attitude to those academic subjects that, in most cases, is caused by several, often intertwined variables (Osborne et al, 2003). According to these authors, it is this enmeshment of variables along with the fact that attitudes are essentially a measure of the subject's expressed preferences and feelings toward an object that makes it extremely difficult to examine attitudes toward science.

Teachers' attitudes toward S&T teaching

One of the main variables that have been identified as essential for the formation of students' attitudes to science is the teacher's attitude to the subject and her/his behaviour in the classroom. The existence of a correlation between attitudes and behaviour is widely accepted and has been identified as an important attitudinal feature by different researchers in social psychology (Ajzen, 1988; Fishbein & Ajzen, 1975) as well as in science education (Koballa, 1988; Shrigley, 1990; Zint, 2002). According to Zint (2002) one, if not the most popular and successful theories in attitude-behaviour research is Fishbein and Ajzen's 'Theory of Reasoned Action' published in 1975 and 1980. The model describes an individual's attitude toward any object as a function of the individual's beliefs about the object as well as the implicit evaluative responses associated with those beliefs. That is, a person who believes that performing a given behaviour will lead to mostly positive outcomes will hold a favourable attitude toward performing the behaviour, while a person who believes that performing the behaviour will lead to mostly negative outcomes will hold an unfavourable attitude (Ajzen & Fishbein, 1980).

In their profound review, Osborne et al (2003) cited several studies indicating that the most positive attitudes to science held by students in all grades were associated with a high level of personal support by the teacher and the comments teachers made in class. Similarly, Fisher, Waldrip, and den Brok (2005) found in their study with 2178 Australian grade 5, 6 and 7 children a positive association between students' attitudes to science learning and the teacher's interpersonal behaviour in the science classroom. That is, students enjoyed learning science more the more their teacher interacted with them before, during and after lessons, the more s/he kept eye-contact, smiled, and provided humour in the classroom (Fisher et al, 2005). However, teachers also benefit emotionally from positive teacher-student interactions. According to Hargreaves (2000), elementary and secondary school teachers attain emotional rewards and 'psychic rewards' from positive feedback from individual students as well as whole class groups. In his qualitative study with 53 teachers, Hargreaves (2000) found substantial differences in elementary and secondary school teachers concerning the type of affective reward and the degree of importance of both emotional and psychic rewards. Emotional rewards due to positive incidences with the whole class were cited as the main cause for adopting positive attitudes toward teaching by all elementary school teachers that responded satisfactorily to the appropriate interview question (Hargreaves, 2000). These teachers felt emotionally rewarded by, for example, being students' most favourite teacher, enjoying humour and informality with students, and experiencing “lots of ‘warm fuzzies’ with their classes” (p. 818). Individual breakthroughs of students have also a positive but less salient impact on elementary school teachers’ attitudes. About half of the interviewed elementary school teachers that responded useably to questions concerning positive incidences with students regarded individual success cases of difficult or demanding students as most emotionally rewarding (Hargreaves, 2000). These individual cases are what Lortie (1975) called the ‘psychic rewards’ of teaching: “Teachers feel rewarded when students show affection toward and regard for them and when students demonstrate that they are enjoying (or have enjoyed) their learning” (cited in Hargreaves, 2000, p. 817). Psychic rewards, therefore, seem to be as dependent on individual student’s learning (cognitive domain) as on the emotional well-being (affective domain) of all students in a class. This stands in contrast to ‘purely’ emotional rewards that are mainly based on close emotional bonds or affective understanding between the teacher and her/his students, and secondarily on students’ cognitive learning. Hargreaves (2000) also found that relatively more secondary than elementary school teachers feel ‘psychologically rewarded’ or satisfied with their teaching when perceiving students as emotionally and cognitively engaged in learning. That is, teachers’ enjoyment, which is one of the major components of the attitude concept, seemingly becomes more positive with the degree of students’ learning – a positive relationship that is further associated with teachers’ expectations for students’ learning that in turn rise with increasing grades.

A positive association between teachers’ attitudes toward teaching and students’ attitudes toward learning has also been described by Stenlund (1995). In his comparative study that was part of a cross-cultural study involving seven nations from North America, Europe, and Asia, Stenlund (1995) investigated the relationship of teachers' perceptions for students and student learning with teachers' enthusiasm or discouragement concerning professional work. Semi-structured, open-ended interviews were conducted with groups of two to 16 secondary school teachers that explored sources of enthusiasm in teaching, sources of discouragement in teaching, and possible solutions to enthusiasm/discouragement in teaching. The analyses, based on frequency distributions and chi-square tests to determine the significance of differences between the participating countries, revealed a consistency of responses regarding students and learning across all countries. One of the main findings is that teachers of most studied countries need students who are responsive, attentive, and eager to learn in order to enhance their own enjoyment in teaching (Stenlund, 1995). Moreover, "teachers appear to attach fairly significant importance to individual student growth and development and the bonds that develop between the teacher and student as precursory conditions through which the teacher gains enthusiasm for his or her work life" (p. 156). These findings are similar to the outcomes described by Hargreaves (2000) regarding the positive association between teachers' attitude to teaching and students' attitude to learning. That is, teachers gain emotional rewards from positive incidences with the whole class as well as psychic rewards from individual student's positive development and the emotional bond that develop between teacher and student (Hargreaves, 2000).

Interestingly, the positive relationship between teachers' attitudes toward teaching and students' attitudes toward learning suggested by Hargreaves (2000) and Stenlund (1995) was proven true not only in regards to teachers' positive stance on the job but also with regard to the discouragement encountered by teachers; that is, negative disposition to their job as found by Stenlund (1995). To be more precise, the main source for teachers' discouragement is the perceived lack of motivation in students (Stenlund, 1995).

<u>Teacher-student interactions – Gender issues in S&T</u>

Research from the 1980s that focused on the association between teachers' attitudes and students' attitudes suggests the occurrence of a pattern with respect to gender and sciences in general and physical sciences in particular (Kahle, Anderson, & Damajanovic, 1991). Kahle et al (1991) investigated attitude changes in Australian and U.S. American science teachers as well as students after the educators participated in one of three workshops. One of the main goals of this quantitative study was to assess whether grade 4/5 science teachers, who participated in a workshop about equity issues, teach an electricity unit differently from their colleagues who participated in a methodology workshop about electricity or colleagues who took the same methodology workshop plus the workshop on equity issues. Another main goal of the study was to examine gender differences in science teachers' perceptions of students' learning before and after the workshop. And lastly, the study aimed to investigate whether female and male students' attitudes toward the learning of science differed depending on the kind of workshop their teacher participated in. Kahle and her colleagues used two different questionnaires with Likert-type questions, one for teachers and one for students, in order to assess changes in teachers' attitudes and to examine gender differences in teachers' attitudes toward science teaching as well as their perceptions of students' attitudes to science learning. One important finding of the study is that both female and male students' confidence in learning physics, which is the scientific subject that is considered most difficult by all participants, increased after their teachers' participation in one of the workshops. Moreover, while male students' confidence improvement was generally lower than female students', the difference in students' confidence before and after the intervention program was considerably larger in females than in males after their teachers' participation in the equity workshop. That is, significantly more female students than male students in the Australian and the US sample gained confidence and interest in doing physical science due to teachers' increased awareness about equity. This result led to the researchers' proposition that a similar improvement in teachers' attitudes toward the teaching of physics occurred – an assumption that has not been proved judging from Kahle et al.'s (1991) article. However, one of the most important findings of the study is that female students' attitudes about physics were more negative than male students' attitudes and that a similar tendency was found in their teachers. Kahle et al (1991) stated "When one relates teachers' perceptions about science for girls and boys to their own attitudes about teaching science, a pattern emerges. Both the Australian female teachers and the overwhelmingly female sample of U.S. teachers stated that they were less skilled and had inadequate knowledge to teach physical science. They also perceived the girls in their classes as less interested and less confident in physical science" (p. 215). The given explanation for these results is that teacher biases and concerns regarding science in general and physics in particular were probably transmitted to the students, particularly to students of the same sex (Kahle et al, 1991).

This unconscious transmission of emotions between teachers and students of the same sex is one example of a behavioural paradigm that can happen in the S&T classroom. Another example would be the affective exchange that occurs between teachers and students of the opposite sex. The way teachers of both genders interact with their students is guided by a gender paradigm (and other paradigms, e.g., racial) that is grounded in both teachers' and students' socialization.

Teachers' behaviour in the S&T classroom that derives from their attitudes to S&T teaching, therefore, may be influenced by their gender and, as a result, may differ depending on the gender of the students they are interacting with. Jones and Wheatley (1990), for example, found that physics and chemistry teachers treat male and female students differently in the classroom due to divergent expectations the educators hold, and different behavioural problems they encounter. Jones and Wheatley's substantial study, which was based on direct classroom observations of 30 physics teachers and 30 chemistry teachers, found statistically significant gender differences in teacher-student interactions. The researchers observed that boys, for example, called out responses to questions significantly more often than girls. Male students also tended to use louder tones of voice when seeking the teacher's attention and asked significantly more procedural questions of teachers than did the female students. Moreover, boys were significantly more often warned by their teacher and received significantly more praise than girls. Particularly noteworthy is that the researchers discovered statistically significant behavioural differences between male and female teachers. Male teachers, for example, asked significantly more direct questions of students than female teachers and male teachers warned boys and girls with approximately the same frequency. Female teachers, on the other hand, had significantly more warning interactions with boys than with girls. One offered explanation for the described gender-related differences in student treatment is that science teachers use feedback as a control mechanism over student behaviour (Jones & Wheatley, 1990). That is, teachers try to gain control over a class by giving boys more positive feedback as well as negative feedback, which is often expressed as behavioural warnings. These warnings, although initially perceived as negative treatment "may in actuality have positive effects on the male student" (p. 869). That is, as further discussed by Jones and Wheatley (1990) girls may feel threatened by teacher criticism and interpret it as lack of ability while boys do not. It has further been suggested that "when male students are more outspoken and confident, then other pupils see this as evidence that males in general are more valued and capable" (Stanworth, 1983, cited in Jones & Wheatley, p. 867). These patterns, therefore, substantiate gender-role behaviours and corroborate the hegemonic societal structure that is mirrored in the S&T classroom.

Gender differences in teacher expectations

Another explanation for gender differences in classroom interactions could be that teachers hold different expectations for students based on gender (Jones & Wheatley, 1990). These expectations could be related to student behaviour as well as their academic performance. One important aspect of student behaviour is how they use their body, how active they are in class, and how they use their voice, which may be different between female and male elementary students. Gender differences in the way and the frequency students interact physically among each other and in the way they use their body during quiet time as well as play time have been found as early as in three-year and five-year old children (Martin, 2008). These gender differences are, according to the researcher, partially corroborated by the pre-school teachers whose physical interactions with girls and boys differed. Martin (2008) observed that boys were more frequently physically restrained or disciplined by teachers than girls. The researcher interpreted this observation as the educators following what they perceive as a ‘hidden school curriculum’ that “demands the practice of bodily control in congruence with the goals of the school as an institution” (p. 206). In other words, the teachers followed what they believed is expected of them by school administration and society, which most likely is in accordance with what they themselves experienced as children and, therefore, expect to happen.

Teachers in Canada tend to hold higher academic expectations for adolescent boys than for girls in mathematics and science but lower expectations in reading and writing (Bussiere et al, 2001). On the other hand, due to the fact that more boys than girls are perceived as disruptive and disaffected and that more girls than boys are seen as diligent and unquestioning learners (Walkerdine, 1989), teachers are more inclined to expect lower academic performance from boys than from girls. Consequently, low performing female students’ needs are more often overlooked than the needs of underachieving male students (Jones, 2005). By interviewing teachers along with female and male students that were identified by those teachers as either high achieving or underachieving, Jones (2005) revealed that teachers in the UK were not aware of the female underachievers in their classroom. The teachers not only perceived girls more often than boys as high achievers, they did not have a clear concept of the underachieving girl. The participating teachers not only identified male students as underachievers twice as often as female students but were convinced that a certain kind of boys were achieving lower than average, which differs from statistics of national test scores in Britain. Other examples of teachers’ misperceptions found by Jones (2005) were that girls are more engaged, self-motivated, hard-working, and well-behaved than boys. Further, they are thought to be more tolerant and accepting of poor teaching than boys. Another misperception that was denied by female students is the assumption that girls, in comparison to boys, are advantaged in learning English and that they like this school subject better (Jones, 2005).

Teacher knowledge

Although a still rather disputed supposition, most educational researchers agree that elementary school teachers' attitudes toward the teaching of S&T are influenced by their knowledge. Besides the difficulty of determining attitudes about S&T teaching, one reason for the indifference in this question may be the complexity of teacher knowledge that makes it extremely difficult to represent it within one overarching framework or theory. In particular, any representation of teacher knowledge needs to reflect its socially constructed and dynamic nature. Another problem lies in the disagreement about what knowledge is of most worth in S&T and, consequently, what knowledge concept has been examined, and in which way. Some studies have focused on teacher content knowledge while others concentrated on teacher pedagogical knowledge. However, it seems problematic to draw a line between content knowledge and pedagogical knowledge since both forms are interconnected and together shape the way S&T is taught. A model that somewhat combines both categories of knowledge is the pedagogical content knowledge (Shulman, 1986). The concept of pedagogical content knowledge integrates the realms of subject matter, student conceptions, teacher understandings of specific learning difficulties, teacher knowledge, and beliefs about purpose as well as knowledge of instructional strategies. Appleton (2002) further discusses what teachers' pedagogical content knowledge in S&T could entail: "knowledge of students, classroom management, assessment, pedagogy, curriculum, context, environment, socioculturalism, and the nature of science" (p. 394). The predicament regarding S&T teachers' knowledge is reflected in some studies. Kumar and Morris (2005), for instance, suggest that their findings of a significant correlation of prospective teachers' attitudes toward mathematics and science with their scientific understanding should be interpreted with caution. The reason for this caution is the lack of consensus among scientists and educators about what form of knowledge (content or pedagogical) impacts scientific understanding of prospective teachers.

It has been suggested that a considerable number of elementary school teachers knowingly (Harlen, 1997; Weiss, Banilower, McMohan, & Smith, 2001) or unknowingly (Garbett, 2003) lack profound factual background in science. Furthermore, the pedagogical knowledge of prospective elementary science/maths teachers, their views and beliefs regarding their teaching methods, and the impact of those variables on their attitudes or behaviours has been investigated quite substantially. Especially in the 1990s, probably because elementary pre-service science teachers' performance in class had been described as limited and of low quality (Schoon & Boone, 1998; Tilgner, 1990), research in those subjects had been intensified. In their summary of literature in science education published in 1990, Finley, Lawrenz, and Heller (1992) delineated 24 studies on teacher behaviour, attitudes, and beliefs, of which two thirds investigated prospective elementary science teachers' attitudes to science teaching alone.

However, ample research shows that elementary teachers who lack content knowledge feel less confident in teaching S&T, and, consequently, attain less positive attitudes about teaching S&T than teachers whose knowledge background is substantial. For example, Weiss et al (2001) reported in their extensive 'Report of the 2000 National Survey of Science and Mathematics Education' that only 18 to 29 percent of non-specialty elementary school teachers (grade K-6) in the US feel very well qualified to teach physical science, earth science, and life science. Similarly, a substantial mixed-method approach study with in-service grade 3/4 and grade 6/7 teachers revealed that participants were well aware of their limited science content knowledge and, consequently, rated their confidence in teaching science rather low (Harlen, 1997). Most interestingly, though, is the fact that the studied elementary school teachers nevertheless thought they are able to teach science by using teaching skills and strategies compulsory for science, including those which would appear to require solid subject knowledge. This apparent contradiction lends support to the idea that confidence to teach does not depend entirely on understanding of the scientific content. According to Harlen (1997), the confidence in teaching science is most likely based on teachers' general pedagogical knowledge that helps them to overcome constraints and facilitates the navigation around topics and units elementary teachers have limited content knowledge in. Garbett (2003), similar to Harlen (1997), found a positive relationship between student teachers' confidence in teaching science and their content knowledge competence. The study, which was based on 57 surveys and tests, investigated first year early childhood student teachers' attitudes by asking them to rate their own confidence in science teaching and to write about their most vivid school memory. Their actual science competence was subsequently assessed through a knowledge test with 73 multiple choice questions covering the subjects biology, chemistry, physics, and astronomy. Afterwards, the students were asked to predict the number of their correct answers in the test to examine their perceived subject knowledge competence. This study design allowed for the investigation of the actual competence as well as the perceived competence of prospective educators. Garbett's (2003) findings suggest that most of the studied teacher candidates had a poor content knowledge base when entering university. Noteworthy is that the majority of teacher candidates were not aware of their lack of content knowledge and that 60 percent thought their background knowledge is adequate to teach science at the early childhood level. As stated by Garbett (2003): "Student teachers seemed confused and ignorant of their own understanding and/or misunderstanding in science" (p. 477). This 'confusion', though, probably had to do with the fact that the cohort was comprised of freshmen who attended their first lecture in the Bachelor of Education program. However, the abovementioned research corroborates the supposition that confidence to teach S&T depends on pedagogical content knowledge and not on subject knowledge alone. It also lends support to the notion that there may be a considerable difference between self-expressed confidence and actual competence.

Attitude change

Specific science-related courses that are tailored to meet the needs of pre-service teachers have been identified as a way to improve the teacher candidates' self-confidence in science teaching and subsequently their attitudes to science and science teaching. Palmer (2001), for example, found through interviews with four Austrian pre-service elementary school teachers that their attitudes toward science and science teaching had substantially changed after their participation in a special course, as can be seen in the following excerpts: "[My attitude] was very negative. I hadn't done science much since

Grade 10 in high school. … Apprehensive more than anything – I didn't feel like I was very good at that subject, and that's probably why it was negative." … The response of the same student after finishing the course: "Yes [my attitude has] definitely changed. I'm looking forward to teaching it and I have quite a bit more confidence… [This subject was] lots of fun. That's something I didn't think I'd ever be able to say – that science was fun. But it was lots of fun." (Palmer, 2001, p. 126). Asked about the reasons for their attitude change from negative to positive, all four interviewees mentioned the tutor's proficiency and aptitude. They highlighted in particular the tutor's enthusiasm and confidence, the clarity of explanations, the use of simple language without scientific jargon, the clear structure of the session, which included an introductory overview, and their opportunity to ask questions regularly. In addition to the excellent tutor's teaching skills, the pre-service teachers put emphasis on the incorporation of a variety of teaching strategies, the practical validity of techniques used, the direct modeling of classroom practice, and the use of hands-on activities. Similarly, as a result of his quantitative pre-test/post-test research on prospective elementary school mathematics teachers, Ezeife (2003) stressed the importance of an enriched teacher-training program. The researcher strongly suggests the frequent use of meaningful "everyday" illustrations and a more learner-oriented, inquiry-based approach to the teaching of subject content besides the teaching of pedagogical strategies in order to enhance prospective teachers' knowledge of and attitudes to mathematics. More evidence for the positive impact of special courses on pre-service elementary school teachers' attitude to and preparation for science teaching were given by several other researchers (Bohning & Hale, 1998; Jarrett, 1998; Klag, 1990; Moore & Watson, 1999; Mulholland & Wallace, 1996; Pederson &

McCurdy 1990; Young & Kellogg, 1993). Bohning and Hale's (1998) research, for example, resulted in improvement in self-confidence due to an inquiry-based methods course, whereby Jarrett (1998) and Klag (1990) described the positive effect of hands-on laboratory experiences in addition to inquiry-based activities. Pederson and McCurdy (1990) stressed on the incorporation of peer-teaching during laboratory sessions since those tutorials had a significant motivating effect on low and high achievers alike. Additionally, Moore and Watson (1999), Mulholland and Wallace (1996), as well as Young and Kellogg (1993) have found that prospective elementary science teachers were most comfortable in a learning environment that provided interesting facts that were relevant to life, contained content useful for teaching, supported the freedom to ask questions, and allowed a slow pace of learning.

As seen from the above-mentioned research, the number of studies showing a positive effect of extended factual and methodological preparation on pre-service elementary school teachers' attitudes to science teaching is quite substantial. However, the correlation between prospective elementary teachers' methodological/subject knowledge and their attitudes toward science as well as toward mathematics has proven elusive despite considerable research. Kumar and Morris' (2005) statistical analyses, for example, resulted in a weak, though significant relationship, between the predictor variables *Attitude toward science*, as well as *Attitude toward mathematics and scientific understanding*. Hence, the instrument used by the researchers to examine the elementary teacher candidates' scientific understanding ('Scientific Understanding Survey' developed by Klapper, DeLucia, & Trent, 1993) was probably not sufficiently refined since it used a questionnaire that consisted of 25 multiple-choice questions on a variety of scientific subjects. An earlier study (Hall, 1990) showed a similar modest improvement in pre-service elementary teachers' attitudes toward science through knowledge enhancement although the same teaching methods (hands-on and discovery-oriented) as in other evidently successful experiments had been applied. Finally, no attitude change has been found in two studies conducted the same year (DeTure, Gregory & Ramsey, 1990; Rice, 1990). While Rice's results indicated that there were no statistically significant differences for either achievement / understanding of concepts or attitude of prospective elementary science teachers, DeTure et al.'s (1990) experimental group showed a significant increase in scientific knowledge but no improvement in attitude toward science and science teaching after participating in a special science content / methods course. However, the majority of reviewed studies indicated that pre-service elementary science teachers' participation in special science courses had a significant positive impact on the student teachers' knowledge and attitude to science and science teaching. A similar effect has been reported on in-service science teachers. Westerback and Long (1990) found that earth science teachers' content knowledge increased and their anxiety levels toward science teaching was reduced after participating in a content-centered program. Similarly, McDermott, Heron, Shaffer, and Stetzer (2006) developed a research-based curriculum for elementary and secondary teachers that revealed good results in the teaching of physical science and physics. Due to the recommended inquiry-oriented teaching approach not only teachers' own understanding of physical phenomena was enhanced but the teachers developed pedagogical content knowledge that enabled them to teach physics in a way students understand, too (McDermott et al, 2006).

Teachers' beliefs

Elementary school teachers' attitudes toward the teaching of S&T are influenced by their beliefs about what knowledge is important in S&T teaching and learning and how this knowledge can be transferred to students. These beliefs or conceptions are formed by teachers' own school experiences as children/adolescents, the concepts they developed during their teacher education and their professional experiences as teachers among other things. It has been suggested, for instance, that most elementary student teachers' school science experience has been a passive, teacher-driven collection of facts, which is why many teachers have problems in developing constructivist inquiry-based teaching strategies in science (see review in Garbett, 2003). Contrarily, in a Swedish study with prospective teachers whose major subjects were mathematics and science, it has been found that about half of the participants had attained a constructivist view of science teaching and learning (Wolf-Watz, 2000). Moreover, for the majority of the interviewed teacher candidates the nature of science as 'experimental' had most significance. This applied approach to science teaching and learning entails that students learn by doing and that they are engaged in hands-on activities (Wolf-Watz, 2000). Interviewees that held this experimental view of science "reported positive feelings about science, such as, 'it's fun, it touches me, interesting, miracle and wonder'" (p. 406). Further, about half of the interviewed prospective science teachers held a perspective on science as 'essential and everyday'. That is, those students believed that "absolutely everything around us is science" (p. 407) and that knowledge about the environment is essential to survive. Many prospective teachers thought that it is important for teachers to have a substantial knowledge about science in order to make the teaching and learning of science more effective (Wolf-Watz, 2000). Further, a substantial number of the studied teacher candidates were well aware of gender issues in the science classroom, which can be seen from statements such as ‘boys push themselves forward’, ‘girls take up less space’, ‘girls are less interested’, ‘teachers choose boy- friendly content’, and ‘girls worry about not doing the right thing’ (p. 408/409). This awareness, though, is no indication for student teachers’ beliefs regarding gender equity in science in general nor does it reveal whether these prospective teachers will incorporate gender issues into their S&T teaching. The integration of social/cultural, philosophical, and historical aspects in science teaching and learning was apparently not as important for most student teachers in Wolf-Watz’s (2000) study. Only a minority of the interviewees thought that cultural and democratic perspectives are important in science education, which, according to the author, implies the belief of science “as a dynamic, human pursuit rather than a fixed body of truth” (p. 410).

The belief that science is a human pursuit is generally not widely accepted due to the common and mostly taught conception that science is purely objective and scientific knowledge is unchangeable. The idea that scientific ‘facts’ are created and shaped by humans and, therefore, influenced by their biography, cultural/social background, and gender is still fairly unknown. As a consequence, the notion of science being a ‘masculine’ subject due to the age-long influence of patriarchical thought and social structures (Watts, 2007) is foreign to most students. This is mainly because of lack of knowledge in the area of philosophy and history of science. The importance of an integration of both philosophy of science and history of science in science education has been emphasized by Elkana (2000), Watts (2007) and several other researchers. This is particularly important in regards to gender. Watts (2007) examined the interrelationships of education, gender and science from a historical perspective. In her article, Watts delineates the role women played in science during the late eighteenth/beginning of the nineteenth century and compares their societal position during that period with the situation of female scientists in the first half of the twentieth century. The researcher describes furthermore how women shaped the way science was taught by giving the example of Jane Marcet who introduced conversations and experiments in the teaching of chemistry in the late eighteenth century.

History of science and philosophy of science are both epistemological domains that cumulate in the concept of nature of science. Given the complexity of the nature of science even for philosophers of science, some of the controversy has centered on the issue of what needs to be included in science education and at what level of complexity. According to Smith and Scharmann (1999), the nature of science can help students and teachers to distinguish between things that are more scientific from those that are less scientific. In other words, it is important to enhance teacher knowledge about the nature of science in order to make them aware of scientific misconceptions they possibly have. This is essential because only teachers who can distinguish between proper scientific conceptions and misconceptions are able to correct children's ideas and naïve views in science. These scientific ideas are, according to Garbitt (2003), often counterintuitive since "children make sense of their experiences and develop their own knowledge and workable theories to explain the world around them" (p. 469/470). What the researcher meant by this can be seen from the example of a scientific misconception she gave; for children "it would appear that the sun goes down rather than the earth is turning"

(p. 469). Hence, if a teacher holds certain misconceptions in science s/he will be unable to correct students' naïve views with the consequence that these misconceptions or beliefs may be perpetuated.

Misconceptions or beliefs persist until they are replaced. Since teachers go through a long process of education and progressively learn new things on the job, one might expect that they undergo a rather vigorous transformation concerning their beliefs; hence, it has been suggested that this is not necessarily the case (Pajares, 1992). In fact, one obstacle about teachers' beliefs as well as anybody else's beliefs is that they are formed early, meaning long before one enters the higher educational system. Another obstacle is that beliefs are generally difficult to change. Pajares (1992) argued that:

> Beliefs are unlikely to be replaced unless they prove unsatisfactory, and they are unlikely to prove unsatisfactory unless they are challenged and one is unable to assimilate them into existing conceptions. When this happens, an anomaly occurs – something that should have been assimilable is resisted. Even then, belief change is the last alternative. (p. 321)

Against the background of the cited 'resistance to change', the following research can be seen as proof that some exceptions exist. Tobin, Briscoe, and Holman (1990), for example, studied the beliefs of one in-service elementary school science teacher in order to test their hypotheses that science teaching is dominated by (1) the view that knowledge is transferred from teacher to students and (2) that this view is prevailing due to teachers' 'constraints' formed by their prior knowledge, beliefs, and experiences. The researchers' hypotheses have been validated since the studied teacher overcame her constraints that the teacher herself thought were unchangeable. To be more precise, the elementary teacher changed her instructional approach to be consistent with a constructivist view of learning and teaching after she realized that knowledge is not simply transferred from teacher to student. This change, however, was a long-term process which entailed new knowledge about science teaching and learning, reflection on interactions with students and colleagues, and critically analyzing the manner in which mathematics and science were taught at the elementary level (Tobin, Briscoe, & Holman, 1990). That it is possible to overcome one's beliefs has also been shown by Stuart and Thurlow (2000). In their study, the researchers observed substantial changes in pre-service elementary school teachers' beliefs after the teachers' participation in a mathematics and science methods course. The course was special in so far as it focused explicitly on the relationship between teachers' beliefs and classroom practice. During the course, the study participants realized that their views about S&T teaching and learning were heavily influenced by their childhood experiences and the internalization of the values, beliefs, and practices of their teachers. Moreover, the pre-service teachers "began to feel a need to ensure that they not pass on counterproductive beliefs to students and to understand their responsibility in breaking the cycle" (Stuart & Thurlow, 2000, p. 118). However, it is indispensable that pre-service as well as in-service teachers bring their beliefs and consequently their attitudes toward science and science teaching to a conscious level in order to re-evaluate and probably change it. Change of teaching practice can, as mentioned before, be difficult to implement not necessarily because of the science teacher's reluctance per se but because her/his beliefs with respect to new content (e.g., the nature of philosophy of science) or pedagogy (e.g., conceptual change of teaching) may differ from the intentions of innovation (van Driel, Beijaard, & Verloop, 2001). As a summary of their literature review on science teacher's practical knowledge, van Driel et al stated that in all studies problems occurred when teachers were asked to put innovations into practice. As the researchers further explained “inconsistencies often occur between teachers’ expressed beliefs and their behaviour in the classroom” (p. 148).

Teachers’ perceptions of the scientist and her/his work

As mentioned earlier, most teachers’ use an applied approach to S&T teaching that entails experimental work and hands-on activities. Oftentimes, teachers are guided in their applied S&T teaching strategy by what they consider ‘the scientific method’, which Lederman, Abd-El-Khalick, Bell, and Schwartz (2002) consider a myth:

> The myth of the scientific method is regularly manifested in the belief that there is a recipe like stepwise procedure that all scientists follow when they do science. This notion was explicitly debunked: There is no single scientific method that would guarantee the development of infallible knowledge. (p. 501)

Seemingly analogous to the confusion about the scientific method is the mystification of the scientist and her/his work. It comes, therefore, as no surprise that some teachers may have adopted misconceptions about scientists and their work. Carter, Stubbs, and Berentson (1996), McDuffie (2001), as well as Rampal (1992) suggest that the majority of science educators (Kindergarten to grade 12; K-12) have inadequate and erroneous conceptions of scientists and their work. Carter, Stubbs, and Berentson (1996), for example, studied science teachers’ images of an environmental scientist at work and found that the K-12 teachers portrayed the work of environmental scientist as purely collecting data in the field. The study participants did not perceive the more important science process skills such as analyzing samples, organizing and interpreting data, making generalizations and conclusions as activities of a scientist. Additionally, the majority of the K-12 science educators studied by Carter, Stubbs, and Berentson (1996), McDuffie (2001), and Rampal (1992) had perceptions of the scientist that were often synonymous with the stereotypical image of a white male. This image of the scientist was first identified by Mead and Métraux (1957) and subsequently confirmed by Chambers (1983) and others (e.g., Thomas & Hairston, 2003). Mead and Métraux's research showed further that students perceive scientists as individuals with limited or no social skills, which is similar to McDuffie's (2001) findings of science teachers. Probably because scientists are not a part of teachers' social circles, 80 to 90 percent of 550 science teachers stated that they would rather invite a social scientist than a scientist to a special social event if they were allowed to invite just one person (McDuffie, 2001). Moreover, the teachers in McDuffie's study as well as Carter et al.'s (1996) research failed to depict science as a collaborative endeavour, which is an indication for the teachers' misconception of the nature of science since today's scientific research is team based.

Summary

The following themes have emerged from this survey of the literature that together support the idea that what is taught in S&T classrooms and in which way it is taught derives from teachers' biography, experiences, knowledge, cultural/social background, and gender, which all amalgamate to teachers' attitudes toward the teaching of S&T.

- Teachers' attitudes toward S&T teaching are closely associated with their beliefs that performing a given behaviour will lead to a certain outcome.
- Students' attitudes about S&T learning are positively correlated with teachers' attitudes to S&T teaching as well as their behaviour in the S&T classroom and vice versa.

- Teachers gain emotional and psychic rewards when individual students as well as the whole class show affection toward and regard for them as well when students perform well and enjoy what is taught.
- Teacher-student interactions in the S&T classroom are influenced by gender.
- Teachers' biases and concerns regarding S&T are transmitted to students, whereas the gender of both teacher and student plays an essential role.
- Teachers' attitudes toward S&T teaching are impacted by their expectations for students in general and for students of different gender in particular.
- Teacher pedagogical content knowledge can influence teachers' confidence in, and their attitudes about, S&T teaching in various and possibly contradictory ways.
- Teachers' attitudes toward the teaching of S&T can possibly be ameliorated by courses that enhance their pedagogical skills as well as their subject knowledge.
- Teachers' attitudes toward the teaching of S&T are influenced by their beliefs about what knowledge is of most worth in S&T, which partially derived from their own school experiences and their teacher education.
- Teachers have a preconceived idea of the nature of science, which is dominated by the widely accepted and commonly taught conception that science is purely objective.
- Teachers' attitudes are affected by their beliefs about the nature of science and those beliefs shape the way they teach S&T.

- Knowledge about the nature of science can help teachers and students to distinguish between things that are more scientific from those that are less scientific.
- Teachers' unawareness of their own beliefs and misconceptions concerning science can lead to a perpetuation of false scientific conceptions.
- Scientific misconceptions and beliefs are difficult to replace.

CHAPTER III

METHODOLOGY

A. Participants

Grade 4 to 8 teachers of 85 elementary schools from two school boards in South-Western Ontario were asked to participate in this study. A sample of 70 participants was recruited and 50 of them completed the on-line questionnaire entirely. Ten of the 50 respondents also participated in a one-on-one interview after completing the questionnaire. 92 percent of the participants were full time staff and all of them taught S&T for at least one year within the last four years.

B. Instrumentation

1. Questionnaire

The on-line survey instrument (see Appendix A), designed by the researcher, consists of five sections with one to ten scales and 82 items in total. The first section consists of ten questions that address background information such as gender, age, educational background, teaching experience (number of years of S&T teaching as well as teaching in general), size and type of current school besides size of current S&T classes. The second section consists of one attitudinal scale with ten Likert-type items that ascertain the participants' attitudes to, and perceptions of, their S&T teaching. In order to measure this complex concept, questions concerning the teachers' enjoyment and confidence in teaching S&T, teachers' perceptions of students in the S&T classroom, or teachers' knowledge of S&T and exchange with colleagues about this subject are employed in this scale. The third section is comprised of three scales with eight to ten items that aim to survey the participants' S&T learning by asking how informed they feel about certain areas in S&T as well as the kinds of resources the participants use to keep informed about S&T issues. The fourth section consists of 15 Likert-type items separated into two scales that seek to measure the extent to which the teacher perceives students' attitudes toward S&T learning and the teacher's awareness of gender differences in students' S&T learning. The fifth section contains four scales with 30 items in total that ask for teachers' perceptions of scientists/engineers, of gender inequalities in the scientific and technological fields, of scientists' and engineers' occupation, as well as the participants' understanding of the nature and importance of S&T.

The Likert-type measures that were used for the scales in the four attribute sections varied in style. Responses to the items in scale II, IVA, IVB, and VB were measured using a five-point Likert-type scale for extent of agreement (rating scale between *strongly disagree* [= 1] and *strongly agree* [= 5]). Responses to the items in scale IIIA and VA were also rated on a five-point Likert-type scale but the rating choices were for level of knowledge (rating scale between *not informed at all* [= 1] and *informed enough to discuss it with experts* [= 5]) and extent of importance (rating scale between *very important* [= 1] and *unimportant* [= 5]) respectively. A four-point scale was used to measure the responses regarding the frequency of visits of establishments for educational purposes per year (rating scale between *never* [= 1] and *six or more times* [= 4]) presented in scale IIIC and responses to the items in scale IIIB were ranked on a frequency of usage scale from one (*used most*) to ten (*used the least*).

Items that encompass a negative statement (e.g., "I avoid using mathematics in my science and technology teaching") were scaled in reverse. Those items are marked with a minus sign (-) in Table 1.

Table 1: Questionnaire scales with attributes and item numbers

Scale	Attribute	Item number*
II	Attitude to S&T Teaching	II1, II2, II3, II4, II5, II6, II7(-), II8, II9, II10(-)
IIIA	Knowledge of New S&T Issues	IIIA1, IIIA2, IIIA3, IIIA4, IIIA5, IIIA6, IIIA7, IIIA8
IIIB	Use of S&T Resources	IIIB1, IIIB2, IIIB3, IIIB4, IIIB5, IIIB6, IIIB7, IIIB8, IIIB9, IIIB10
IIIC	Extended Knowledge	IIIC1, IIIC2, IIIC3, IIIC4, IIIC5, IIIC6, IIIC7, IIIC8, IIIC9
IVA	Perception of Students' Attitude	IVA1, IVA2(-), IVA3(-), IVA4(-), IVA5(-), IVA6, IVA7, IVA8(-)
IVB	Perception of Gender Differences in Students	IVB1, IVB2, IVB3, IVB4, IVB5, IVB6, IVB7
VA	Perception of Scientific Approach	VA1, VA2, VA3, VA4, VA5, VA6, VA7, VA8, VA9, VA10
VB	Beliefs about Scientists and S&T	VB1(-), VB2, VB3(-), VB4(-), VB5, VB6, VB7, VB8, VB9, VB10

* Items with no indication are scored 1, 2, 3, 4, 5 for responses ranging from 'strongly disagree' (1) to 'strongly agree' (5) respectively; items designated (-) are scored in reverse manner.

Validity

In order to assess how accurately the measuring instrument measures the constructs it purports to measure, the questionnaire's content and construct validity were examined.

Content validity: Three faculty education members at the University of Windsor, two of them experts in science teaching and one in survey design, were asked to critically comment on the validity of the questionnaire before it was administered to the study participants. The views of these faculty members were taken into consideration in modifying the questionnaire to produce the final version used in the study.

Construct validity: The degree to which the instrument provides accurate results had to be assessed after the data collection due to the fact that the questionnaire could not be pre-tested because of limited participation. For the purpose of establishing construct validity, the relationships (Pearson's correlation coefficients) between the items of each scale that measures a common underlying attributable construct were computed (see Chapter IV, section A 2).

2. Interview

The semi-structured, one-on-one interviews were conducted at a public place away from school premises using a set of 20 open-ended questions (see Appendix B). The questions centred on four main topics that were already investigated in the questionnaire to compare the answers in both instruments, to further explore teachers' attitudes to S&T, and to tease out possible gender bias. Those four topics were: (a) teachers' approach to S&T teaching; (b) teachers' perceptions of the students in their S&T classroom; (c) teachers' perceptions of scientists; and (d) teachers' perceptions of gender bias. Probes were used whenever it was necessary to either clarify a given answer or to elicit more information. The duration of the ten interviews varied between half an hour and one hour and 15 minutes, depending on the elaboration of the answers.

Before the interview, each interviewee was informed about the procedure for the interview, her/his informed consent was sought, and some demographic questions to confirm the Participant's gender, age, educational background, and teaching experiences were posed. The interviews were recorded, transcribed, and coded for analysis. The coding process was carried out by reading the transcripts at least two times, dividing the text into labelled segments by highlighting sentences or whole passages during the second reading, examining the coded text segments for overlap and redundancy, and collapsing the codes into the four broader themes mentioned above. Specific text data that could be used as citation to demonstrate or explain an observed phenomenon were selected during this analytical process.

C. Design and Procedures

In order to investigate the relationships among grade four to grade eight teachers' attitudes to S&T teaching and their perceptions of S&T, scientists, students' attitude to S&T learning, gender differences in students' learning, as well as their view of gender disparity in scientists, both quantitative and qualitative methods were used. The explanatory mixed methods design was employed to first collect quantitative data and then collect qualitative data to elaborate on the quantitative results.

Permission to survey grade 4 to 8 teachers of two school boards in South-western Ontario had been granted by the University of Windsor Research Ethics Board (REB) and both school boards prior to the start of this study. Once the written approval was received, the survey instrument along with a letter of information for consent to participate in the research survey was posted at a University of Windsor survey Web site specifically created for this study. Subsequently, a letter requesting permission to survey grade 4 to 8 teachers (see Appendix E) and to forward an attached letter of information (see Appendix F) to the teachers at their school was sent by regular mail to all principals of one of the two school boards (school board A) and by e-mail to all principals of the other school board (school board B). Since only two responses were obtained after four weeks, the researcher followed up by calling those principals that did not decline participation after they received the first letter/e-mail (school board A) or by sending them an e-mail reminder (school board B). A second reminder was e-mailed to those principals of both school boards that distributed the letter of information to their grades 4 to 8 teachers that teach S&T at their school. At the same time, the researcher started to phone principals in order to ask for their permission to meet with the appropriate teachers at their schools. Four schools from school board A and six schools from school board B were visited between May 7 and May 30, 2008. Since the participants were extremely busy with regular work due to the approaching end of the school year and, as a consequence, did not complete the survey, and because more and more principals of both school boards refused any further involvement in the study, no more attempts to recruit additional participants were carried out beyond June 13, 2008. The survey Web site was closed on June 16, 2008.

D. Data Analyses

SPSS 16 was used to analyze the quantitative data and Word 2003 and Excel 2003 were used to select and code the qualitative data.

CHAPTER IV

RESULTS

A. Survey

1. Demographics

The total number of survey responses was 70. Seventeen of the participants did not complete the demographic question regarding their S&T teaching experience and another three participants responded insufficiently since major parts of the most important attitudinal sections were not completed. Consequently, the number of responses that were analyzed was 50.

Excluded from the statistical analyses was the scale 'Use of S&T Resources' because a substantial number of participants did not complete the scale or ranked the sources of information incorrectly by not using a scale from one to ten as required. Also excluded from the analyses were the last two scales of the questionnaire that asked the participants to write down what they think are (a) the five most important skills a scientist should have (scale VC); and (b) the five most important school subjects an elementary school should offer (scale VD), since only 36% of the participants completed scale VC and no participant completed scale VD usefully for statistical analysis.

Age and Gender

Of the 50 participants, 74% were female (N=37) and 26% were male (N=13). The highest percentage of participants (40%) was in the age range of 31 to 40 years. 24% and 22% were in the range of 24 to 30 years and 41 to 50 years, respectively. Another 14% of participants were between 51 and 65 years old. About one third of the female participants were between 24 and 30 years old, another third between 31 and 40 years, and the last third was about equally distributed between the age ranges of 41 to 50 years and 51 to 65 years. Slightly different was the distribution among the male participants: more than half of the males were between 31 and 40 years old, about one third was between 41 and 50 years old, and a bit under a tenth of the males was either in the age range of 24 to 30 years or 51 to 65 years (Appendix G).

Educational Background and Gender

The response rate to the questions regarding the science and mathematics courses taken in high school was between 42% and 62% (Table 2). 16 participants (70% of the respondents that answered the appropriate question) completed grade 13 mathematics; 13 participants (42% of the respondents that answered the appropriate question) completed grade 13 biology; 11 participants (37% of the respondents that answered the appropriate question) completed grade 13 chemistry; and 9 participants (43% of the respondents that answered the appropriate question) completed grade 13 physics. The percentage of respondents that had grade 12 as their highest grade completed was 45% in biology, 43% in chemistry, 29% in physics, and 22% in mathematics (see Table 2 below).

On average, the participants that responded to the question concerning the science and mathematics courses taken in high school took math for 4.1 years (STD: 1.35, N=35), biology for 3.3 years (STD: 1.55, N=31), chemistry for 3.0 years (STD: 1.73, N=32), and physics for 2.35 years (STD: 1.70, N=26).

Table 2: High school courses taken by participants

	Responses (of Total)		Grade 13		Grade 12	
	N	**%[1]***	**N**	**%***	**N**	**%***
Biology	31	62	13	42	14	45
Chemistry	30	60	11	37	13	43
Physics	21	42	9	43	6	29
Mathematics	23	46	16	70	5	22

[1]Percentage of responses. ***Approximation.

Twenty-three females (62% of all female participants in the sample) and eight males (62% of all male participants in the sample) responded to the questions regarding the biology courses they took in high school. 48% of those female respondents and 25% of those male respondents completed grade 13 biology in high school (Table 3).

Twenty-two females (59% of all female participants in the sample) and 8 males participants (62% of all male participants in the sample) responded to the questions regarding the chemistry courses they took in high school. 41% of those females and 15% of those males completed grade 13 chemistry (Table 3).

Fifteen females (41% of all female participants in the sample) and 6 males (46% of all male participants in the sample) responded to the questions regarding the physics courses they took in high school. 33% of those females and 67% of those males completed grade 13 physics in high school (Table 3).

Seventeen females (46% of all female participants in the sample) and 6 males (46% of all male participants in the sample) responded to the questions regarding the mathematics courses they took in high school. 65% of those females and 83% of those males completed grade 13 mathematics in high school (Table 3).

Table 3: High school courses taken by participants - gender

	FEMALES		MALES	
	N[1]	% within gender*[2]	N	% within gender*[3]
Biology	11	48	2	25
Chemistry	9	41	2	25
Physics	5	33	4	67
Mathematics	11	65	5	83

[1]Number of participants that took grade 13 in high school in respective subject; [2]Percentage of females; [3]Percentage of male respondents; *Approximation.

All participants that responded to the question concerning their university degree (N=49) obtained a bachelor's degree in education and three of them achieved a master's degree in education as well. 13 of all participants obtained a bachelor's degree in science (B.Sc.). Eleven of the participants with a B.Sc. were female (85%) and two participants (15%) were male. Overall, about 30% of all female participants and 15% of all male participants had a bachelor's degree in science.

Teaching Experience

The number of years of general teaching experience ranged from one year (N=1) to 28 years (N=1). The number of years of S&T teaching experience ranged from one year (N=5) to 28 years (N=1). The average (mean) of all 50 participants was 9.6 years (STD: 6.64) of general teaching experience and 6.5 years (STD: 5.81) of S&T teaching experience. The median was 7.5 years for general and 5 years for S&T teaching experience.

2. Reliability and Validity

The Cronbach alpha reliability coefficient was used as an index of scale internal consistency. Table 4 shows the Cronbach alpha reliability coefficients, which ranged from 0.936 (scale IIIA) to 0.425 (scale VB). The Cronbach α coefficients suggest that all scales are internally consistent.

Table 4: Cronbach α of attribute scales

Scale	Scale Title	Cronbach α
II	Attitude to S&T Teaching	0.817
IIIA	Knowledge of S&T Issues	0.936
IIIC	Extended Knowledge	0.696
IVA	Perception of Students' Attitudes	0.861
IVB	Perception of Gender Differences in Students	0.852
VA	Perception of Scientific Approach	0.900
VB	Beliefs about Scientists and S&T	0.425

Construct Validity

The Pearson's product-moment correlation coefficients of one item with all other items of each scale that measured one of the five investigated constructs, was used as an index of construct validity. The constructs were: (1) *Teacher's Attitude to S&T Teaching*; (2) *Teacher's Perception of Students' Attitudes*; (3) *Teacher's Perception of Gender Differences in Students*; (4) *Teacher's Perception of the Scientific Approach*; and (5) *Teacher's Beliefs about Scientists and S&T*.

The correlational analysis of the first scale, *attitude to S&T teaching*, resulted in 14 statistically significant relationships at the 0.01 significance level (two-tailed) and nine statistically significant relationships at the 0.05 significance level (two-tailed) out of 45 possible relationships. Each item correlated significantly with at least one of the other nine items and six items showed five or six significant correlations with other items of the scale. The item 'I can tell that students understand what I explain in my science and technology class' showed, with seven correlations, the highest number of statistically significant relationships ($r = 0.317 – 0.631$, $p < 0.01$ / $p < 0.05$). The item 'Motivating students to participate in class activities is easy for me' showed positive correlations with one other item of this scale only and had, therefore, the lowest number of statistically significant relationships ($r = 0.328$, $p < 0.05$). The strongest significant correlation was between the item 'I think I have adequate training to teach science and technology' and the item 'I consider myself a science and technology expert' ($r = 0.814$, $p < 0.01$). The weakest significant correlation was between the item 'I think I have adequate training to teach science and technology' and the item 'I enjoy discussing scientific and technological topics with colleagues' ($r = 0.292$, $p < 0.05$). (Appendix H)

The correlational analysis of the scale, *perception of students' attitudes*, revealed that this scale is valid with 21 statistically significant relationships at the 0.01 significance level (two-tailed) and six statistically significant relationships at the 0.05 significance level (two-tailed) out of 28 possible relationships. All items, with the exception of two items that correlated significantly with six other items, showed seven significant correlations with other items of the scale, which is the highest possible number. The strongest significant correlation was between the item 'Students are interested in topics covered in the science and technology class' and the item 'Students enjoy discussing scientific problems in class' ($r = 0.704$, $p < 0.01$). The weakest significant correlation was between the item 'Students have difficulties understanding scientific concepts' and the item 'Students enjoy discussing scientific problems in class' ($r = 0.300$, $p < 0.05$). (Appendix H)

The correlational analysis of the scale, *perception of gender differences in students*, resulted in 13 statistically significant relationships at the 0.01 significance level (two-tailed) and six statistically significant relationships at the 0.05 significance level (two-tailed) out of 21 possible relationships. One item correlated significantly with four other items, two items had a positive relationship with five other items, and four items showed, with six significant correlations, the highest possible number of this scale. The item ‘Female and male students participate to the same extent in out-of-school science and technology activities’ showed, with six correlations at the 0.01 significance level, the highest number of statistically significant relationships ($r = 0.374 – 0.578$, $p < 0.01$). The strongest significant correlation was between the item ‘Female and male students show the same amount of interest in science and technology’ and the item ‘Female and male students are equally motivated to learn science and technology’ ($r = 0.858$, $p < 0.01$). The weakest significant correlation was between the item ‘Female and male students show the same degree of interest in hands-on activities’ and the item ‘Female and male students need about the same amount of extra help’ ($r = 0.281$, $p < 0.05$). (Appendix H)

The correlational analysis of the scale, *perception of the scientific approach*, is valid since it resulted in 26 statistically significant relationships at the 0.01 significance level (two-tailed) and three statistically significant relationships at the 0.05 significance level (two-tailed) out of 45 possible relationships. Each item correlated significantly with at least three of the other nine items, most items exhibited statistically significant relationships between five and seven items, and two items showed significant correlations with eight other items of the scale (seven of them at the 0.01 significance level). The strongest significant correlation was between the item ‘Respect for the environment is important for meaningful work in science and technology’ and the item ‘Respect for living things is important for meaningful work in science and technology’

($r = 0.951$, $p < 0.01$). The weakest significant correlation was between the item 'Experimentation is an essential habit of mind in science and technology' and the item 'Integrity in observation is an essential habit of mind for meaningful work in science and technology' ($r = 0.342$, $p < 0.05$). (Appendix H)

The correlational analysis of the scale, *beliefs about scientists and S&T*, resulted in five statistically significant relationships at the 0.01 significance level (two-tailed) and two statistically significant relationships at the 0.05 significance level (two-tailed) out of 45 possible relationships. The strongest significant correlation was between the item 'Scientists and engineers do not socialize as much as people who work in non-scientific fields' and the item 'Scientists and engineers are introverted' ($r = 0.689$, $p < 0.01$). The weakest significant correlation was between the item 'New technological inventions pose too many risks for the environment' and the item 'Scientists and engineers are devoted to their work' ($r = 0.353$, $p < 0.05$). (Appendix H)

3. Attributes

Descriptive Statistics

Attitude to S&T Teaching (scale II): The mean score value for this scale was 3.89. The highest mean value (4.42, STD 1.115; reverse-scaled) was calculated for the statement 'I enjoy teaching science and technology' and the lowest mean value (2.84, STD 1.251) was calculated for the statement 'I consider myself a science and technology expert'.

Knowledge of S&T Issues (scale IIIA): The mean score value for this scale was 2.80. The participants considered themselves as more informed in regards to environmental issues (highest mean value: 3.52, STD 0.930) and the least informed about nanotechnology (lowest mean value: 1.88, STD 0.982).

Perception of Students' Attitudes (scale IVA): The mean score value for this scale was 3.43. The highest mean value (4.06, STD 0.867) was calculated for the statement 'Students are interested in topics covered in the science and technology class' and the lowest mean value (2.68, STD 1.039) was calculated for the statement 'Students have no difficulty with scientific thinking'. The five negative statements were in the range between 3.10 and 3.60 (STD: 1.010 – 1.203, respectively, reverse-scaled).

Perception of Gender differences in Students (scale IVB): The mean score value for this scale was 3.40. The statement 'Female and male students are equally motivated to learn science and technology' had the highest mean value (3.68, STD 0.999) and the statement 'Female and male students participate to the same extent in out-of-school science and technology activities' was scored the least (2.94; STD 0.956).

Perception of Scientific Approach (scale VA): The mean score value for this scale was 4.49. Most participants considered 'Respect for the environment' as essential for meaningful work in S&T (mean 4.66, STD 0.111). 'Commitment to accuracy', 'Precision', and 'Experimentation' were rated as the least important habits of mind for working in S&T (mean of all three variables: 4.32; STD 0.118, STD 0.126, STD 0.920, respectively).

Belief about Scientists and S&T (scale VB): The mean score value for this scale was 3.92. The highest mean value (4.87, STD 0.091, reverse-scaled) was calculated for the statement 'The world would be a better place without science and technology' and the lowest mean value (2.89, STD 0.153) was calculated for the statement 'Scientists and engineers are more interested in research than in teaching'.

The highest mean score (4.49) was found in the scale that measured the participants' *perceptions of scientific approach* and the lowest mean score (2.80) was found in the scale that measured the teachers' *knowledge of S&T issues*. The mean values of all scales are shown in Table 5.

Table 5: Mean values of attribute scales

	Scale	Mean
Attitude to S&T Teaching	II	3.89
Knowledge of S&T Issues	IIIA	2.80
Perception of Students' Attitudes	IVA	3.43
Perception of Gender Differences in Students	IVB	3.40
Perception of Scientific Approach	VA	4.49
Belief about Scientists and S&T	VB	3.92

Correlational Analyses

The bivariate relationships were assessed by computation of the Pearson's product-moment correlation coefficients using z-scores (Table 6). The correlational analyses resulted in six statistically significant relationships at either the 0.01 or 0.05 significance level (two-tailed), whereas three scales showed positive correlations with two other scales. These are: (1) The *attitude to S&T* scale with the scales, *knowledge of new S&T issues* and *perception of students' attitude;* (2) the *knowledge of new S&T issues* scale with the scales, *perception of students' attitudes* and *perception of gender differences in students*; and (3) the *perception of gender differences in students' attitudes* with the scales *perception of students' attitudes* and *beliefs about scientists and S&T.*

Table 6: Pearson Correlation Coefficients of Attribute Scales

		Attitude to S&T Teaching	Knowledge of S&T Issues	Perception Students' Attitude	Perception Gender differences	Perception Scientific Approach
Knowledge of New S&T Issues (IIIA)	Pearson Correlation	.663**				
	Sig. (2-tailed)	.000				
	N	50				
Perception Students' Attitude (IVA)	Pearson Correlation	.365**	.352*			
	Sig. (2-tailed)	.009	.012			
	N	50	50			
Perception Gender differences in Students (IVB)	Pearson Correlation	.255	.313*	.452**		
	Sig. (2-tailed)	.074	.027	.001		
	N	50	50	50		
Perception Scientific Approach (VA)	Pearson Correlation	-.060	-.106	-.180	-.212	
	Sig. (2-tailed)	.691	.478	.225	.152	
	N	47	47	47	47	
Beliefs about Scientists and S&T (VB)	Pearson Correlation	.190	.177	-.001	.352*	-.165
	Sig. (2-tailed)	.206	.239	.993	.016	.274
	N	46	46	46	46	46

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Figures 1a and 1b illustrate the two strongest correlations between the scale that measured *attitude to S&T* and *knowledge of new S&T issues* ($r = 0.452$, $p < 0.01$; see 1a below) and between *perception of students' attitudes to S&T learning* and *perception of gender differences in students' attitudes* ($r = 0.452$, $p < 0.01$; see 1b below).

Figure 1a

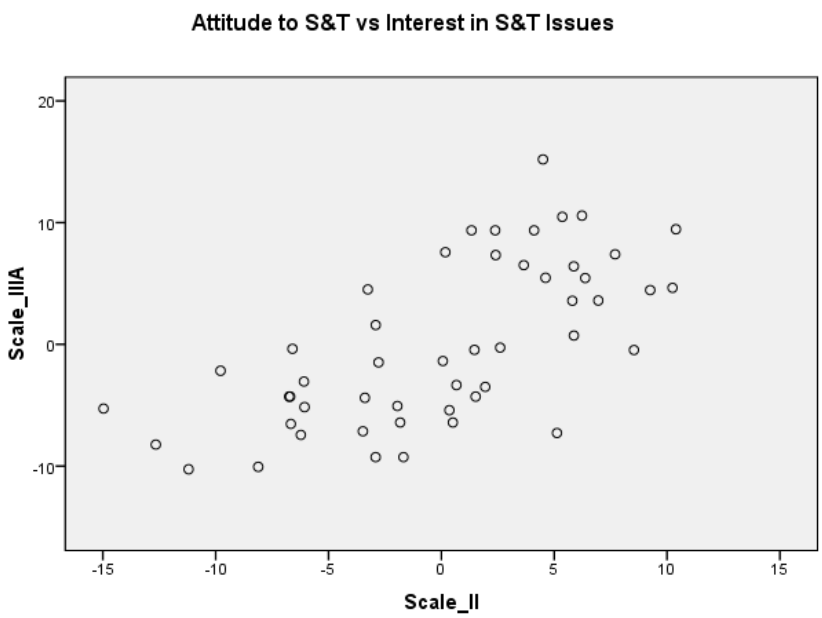
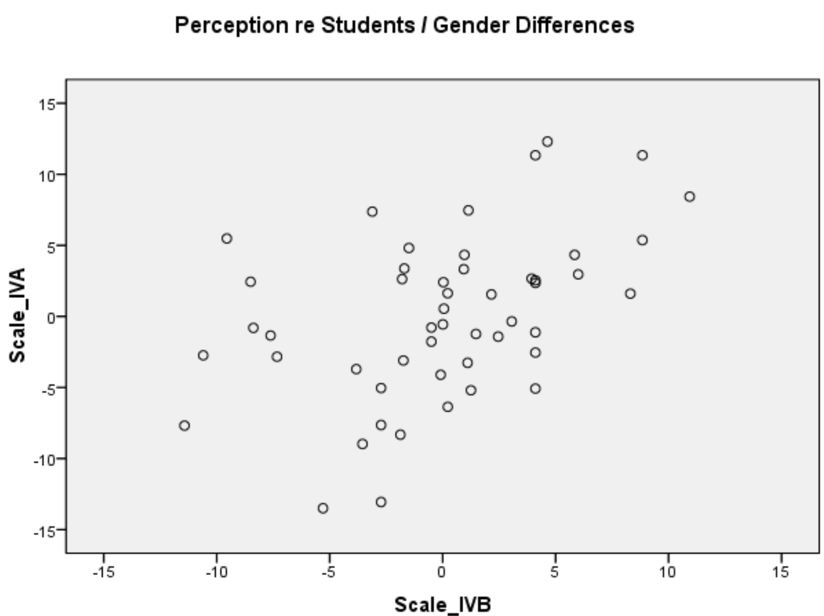


Figure 1b



Group Differences

Gender

As shown in Table 7, the independent samples T-test showed no significant differences between the two gender groups (female, male) either in regards to the variances or the means of the *attitude to S&T* scale (F = 0.806, p >0.05; t = -1.132, p >0.05). There were also no significant differences among the means of the other five attribute scales *knowledge of S&T issues, perceptions of students' attitudes to S&T learning, perceptions of gender differences in students' attitudes to S&T, perceptions of scientific approach*, and *beliefs about scientists and S&T* (t-values between -1.486 and 1.608). However, a significant difference in the variances of the scale *perceptions of scientific approach* has been found (F: 6.763, p < 0.05).

Table 7: Independent Samples t-test of Group Differences - Gender

[Equal variances assumed]	Levene's Test		t-Test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Diffe-rence	95% Confidence Interval of the Difference Lower	Upper
Attitude to S&T	.806	.374	-1.132	48	.263	-2.241	1.980	-6.223	1.741
Knowledge S&T issues	1.317	.257	-1.486	48	.144	-3.202	2.154	-7.534	1.130
Perception students' attitude	1.711	.197	1.608	48	.115	2.958	1.840	-.742	6.659
Gender differences student	.034	.855	1.144	48	.258	1.940	1.695	-1.469	5.348
Perception scientific approach	6.763	.013	-.491	45	.626	-.893	1.819	-4.556	2.771
Belief about scientists & S&T	.320	.574	-.429	44	.670	-.554	1.290	-3.155	2.047

Additionally, Crosstabs and Chi-Square tests were computed with the variable gender (dependent variable) and each of the four variables concerning high school courses taken (independent variable) but no significant results was found. Overall, the Chi-Square tests showed that the numbers of cases are too low. Between 9 cells (90%) and 6 cells (75%) were below 5.

<u>Groups with and without science degree:</u>

Table 8: The independent samples T-test showed no significant differences in the attitude to S&T between the two groups (teachers with a bachelor's degree in science or without a bachelor's degree in science).

Table 8: Independent Samples t-Test for groups with BSc or without BSc

Equal variances assumed	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper
Attitude to S&T	3.975	.052	-1.814	47	.076	-3.566	1.966	-7.520	.388

While the comparison of the groups in the overall scale *attitude* did not result in significant differences, the Chi square test revealed significant score differences in the individual variable, *belief in adequate training* [$\chi 2$ (8, N = 50) = 18.60, p = 0.017] and the variable, *confidence in expertise*: [$\chi 2$ (8, N = 50) = 16.67, p = 0.034]. Teachers with a BSc believed more strongly that they have adequate training to teach S&T than their counterparts without a BSc (mean = 4.54, STD 1.127 and mean = 3.36, STD 1.376, respectively) and they considered themselves S&T specialists more often than those without a BSc (mean = 3.77, STD 1.166 and mean = 2.53, STD 1.134, respectively).

Groups with different science teaching experiences

The independent samples T-test showed no significant differences between the two groups (group 1: teachers with science teaching experience of less than five years; group 2: teachers with science teaching experience of more than five years [median]) either in regards to the variances or the means (Table 9). Five years was chosen as the cut-off point because this is the median of the population.

Table 9: Independent Samples t-Test for two groups with different science teaching experiences

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Difference	
									Lower	Upper
attitude to S&T (II)	Equal variances assumed	.281	.598	1.468	48	.149	2.231	1.520	-.824	5.286

Groups with different general teaching experiences:

Table 10 shows that neither the Levene's Test for Equality of Variances nor the T-test for Equality of Means (independent samples) showed significant differences between the group of teachers with general teaching experience of less than eight years and the group of teachers with more than eight years of general teaching experience in the attitude to S&T teaching scale. Eight years of experience was chosen as the cut-off point because this is the median of the population.

Table 10: Independent Samples t-test for Groups with different General Teaching Experiences

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper
Attitude to S&T	Equal variances assumed	5.88	.447	.232	48	.817	.360	1.551	-2.759	3.479

<u>Multiple regression analyses</u>

Multiple regression analyses were conducted with the overall scales, *attitude to S&T*, *knowledge of S&T issues*, and *gender differences in students* as dependent variables since all three scales yielded significant correlations with two other scales. The stepwise approach used to enter the independent variables into the regression analyses resulted in the removal of those scales that did not meet the criteria set at Probability-of-F-to-enter ≤ .05 and Probability-of-F-to-remove ≥ .10. The removed scales are as follows:

(1) Dependent variable *attitude to S&T*:

The scale, *knowledge of S&T issues*, was entered in the regression analysis as sole independent variable because *students' attitude to S&T* did not meet the probability criteria (Probability-of-F-to-enter ≤ .05 and Probability-of-F-to-remove ≥ .10).

(2) Dependent variable *knowledge of S&T issues*:

The scale, *students' attitude to S&T*, was entered in the regression analysis as the sole independent variable because *gender differences in students* did not meet the probability criteria (Probability-of-F-to-enter ≤ .05 and Probability-of-F-to-remove ≥ .10).

(3) Dependent variable *gender differences in students*:

In model 1 the scale, *students' attitude to S&T*, was entered in the regression analysis as the sole independent variable because *gender differences in students* did not meet the probability criteria (Probability-of-F-to-enter ≤ .05 and Probability-of-F-to-remove ≥ .10). In model 2, both scales, *gender differences in students*, and, *beliefs about scientists and S&T*, were entered in the regression analysis since the probability of both scales was ≤ .05.

Dependent variable *attitude to S&T*

As can be seen in the summary of the regression model (Table 11), the sample multiple correlation coefficient (R) with the dependent variable is 0.66, which allows a good prediction, and R^2 is 0.44, which indicates that approximately 44 percent of the variance of the *attitude* scale in the sample can be accounted for by the linear combination of the measure, *knowledge of S&T issues*. The analysis of variance showed a significant relationship between the *attitude to S&T* scale and the predictor, *knowledge of S&T issues*, $F(1, 48) = 37.53$, $p = 0.000$ (Table 12). Table 13 provides the unstandardized coefficient (B = .60) and the standardized coefficient (Beta = .66) for the independent variable, along with the t-value (t = 6.13) and its significance level that tests whether the Beta coefficient is different from zero ($p = .000$). Using the unstandardized B coefficient, the regression equation can be calculated as follows:

Y (*attitude to S&T*) = 25.368 + (0.603 x *knowledge of S&T issues* scores).

Table 11: *Attitude to S&T* (dependent variable) with *Knowledge of S&T Issues*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.662[a]	.439	.427	4.663

a. Predictors: (Constant), knowledge S&T issues

Table 12: *Attitude to S&T* with predictor *Knowledge of S&T Issues*

ANOVA[b]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	815.783	1	815.783	37.525	.000[a]
	Residual	1043.497	48	21.740		
	Total	1859.280	49			

a. Predictors: (Constant), knowledge S&T issues

b. Dependent Variable: attitude to S&T

Table 13: Unstandardized coefficient B and standardized coefficient Beta

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	25.368	2.302		11.019	.000
	knowledge S&T issues	.603	.098	.662	6.126	.000

a. Dependent Variable: attitude to S&T

The regression analysis suggests that around 44 percent of the variation of attitudes toward S&T teaching among teachers in this sample can be explained by their knowledge of or interest in novel S&T issues. Those in the sample that ranked their level of knowledge in certain S&T areas such as environmental issues, space exploration, or nanotechnology high, tend to have more positive attitudes toward S&T teaching than those that rated their level of information low.

Dependent variable *knowledge of S&T issues*

The summary of the model (Table 14) provides the sample multiple correlation coefficient (R = 0.36) and its squared value (R^2 = 0.13), which indicates that approximately 13 percent of the variance of the *knowledge* scale in the sample can be accounted for by the linear combination of the measure, *students' attitude to S&T*. The analysis of variance showed a significant relationship between the *knowledge of S&T issues* scale and the predictor *students' attitude to S&T*, $F(1, 48) = 7.04$, $p = 0.01$ (Table 15). Table 16 provides the unstandardized coefficient (B = 0.42) and the standardized coefficient (Beta = .36) for the independent variable, along with the t-value (t = 2.65) and its significance level that tests whether the Beta coefficient is different from zero (p = 0.011). Using the unstandardized B coefficient, the regression equation can be written as follows:

Y (*knowledge of S&T issues*) = 10.961 + (0.417 x *students' attitude to S&T*).

Table 14: *knowledge of S&T issues* (dependent variable) with *students' attitude to S&T*

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.358[a]	.128	.110	6.382

a. Predictors: (Constant), students' attitude S&T

Table 15: *knowledge of S&T issues* with predictor *students' attitude to S&T*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	286.858	1	286.858	7.043	.011[a]
	Residual	1955.142	48	40.732		
	Total	2242.000	49			

a. Predictors: (Constant), students' attitude S&T

b. Dependent Variable: knowledge new S&T issues

Table 16: Unstandardized coefficient B and standardized coefficient Beta for the independent variable *students' attitude to S&T*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.961	4.404		2.489	.016
	students' attitude to S&T	.417	.157	.358	2.654	.011

a. Dependent Variable: knowledge S&T issues

The regression analysis suggests that around 13 percent of the variation of the knowledge of or interest in novel S&T issues among teachers in this sample can be explained by their perceptions of students' attitudes toward S&T learning. Those participants in the sample that scored high in their perceptions of students' attitudes toward S&T learning tend to have more knowledge of, or interest in, new S&T issues.

Dependent variable *gender differences in students' attitude to S&T learning*

As can be seen in the model summary (Table 17), the sample multiple correlation coefficient of the strongest predictor, *students' attitude to S&T* with the dependent variable (model 1) is R = 0.48 and R^2 = 0.23. The coefficient of the combined variables, *students' attitude S&T* and *beliefs about scientist and S&T*, with the dependent variable (model 2) yielded a stronger relationship and better prediction since R = 0.63 and R^2 = 0.39. Table 18 shows the results of the analysis of variance for both models. Model 1 as well as model 2 generated a significant relationship between the *gender differences in students' attitudes to S&T learning* scale, $F(1, 44) = 13.49$, $p = .001$, and the two predictors, *students' attitudes to S&T,* and the combined variable *students' attitudes to S&T / beliefs about scientists and S&T*, $F(2, 43) = 13.82$, $p = .000$. The unstandardized and the standardized coefficients for the independent variables, along with the t-values and their significance levels are shown in Table 19. The final regression equation, using the B coefficients from model 2, can be written as follows:

Y (*gender differences students*) = -10.001 + (0.435 x *students' attitudes to S&T* scores) + (0.562 x *beliefs re scientist and S&*T scores).

Table 17: *gender differences in student attitude to S&T* (dependent variable) with *students' attitudes to S&T*, and the combined variables *students' attitudes to S&T / beliefs about scientists and S&T*

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.484[a]	.235	.217	4.778
2	.626[b]	.391	.363	4.310

a. Predictors: (Constant), students' attitude S&T

b. Predictors: (Constant), students' attitude S&T, beliefs about scientist and S&T

Table 18: *gender differences in students attitude to S&T* with the predictors *students' attitude S&T* and *students' attitude S&T / beliefs about scientist*

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	307.879	1	307.879	13.486	.001[a]
	Residual	1004.491	44	22.829		
	Total	1312.370	45			
2	Regression	513.496	2	256.748	13.820	.000[b]
	Residual	798.874	43	18.578		
	Total	1312.370	45			

a. Predictors: (Constant), students' attitude S&T

b. Predictors: (Constant), students' attitude S&T, beliefs about scientist and S&T

c. Dependent Variable: gender differences students

Table 19: Unstandardized coefficient B and standardized coefficient Beta for the independent variable *student attitude S&T* and *students' attitude S&T / beliefs about scientist and S&T*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.690	3.361		3.478	.001
	students' attitude S&T	.447	.122	.484	3.672	.001
2	(Constant)	-10.006	7.192		-1.391	.171
	students' attitude S&T	.435	.110	.472	3.967	.000
	beliefs scientist and S&T	.562	.169	.396	3.327	.002
a. Dependent Variable: gender differences students						

The regression analysis suggests that approximately 40 % of the variance of the gender differences in *students' attitudes to S&T learning* scale in the sample can be accounted for by the linear combination of the *students' attitude to S&T and beliefs regarding scientists and S&T* measures. The increased prediction of the variance in the overall scale, *gender differences in students' attitude to S&T learning*, in model 2 probably occurred because no relationship exists between both predictors, *students' attitudes to S&T*, and *beliefs regarding scientists and S&T* (r = -0.001), thereby strengthening the relationship between the dependent variable and the combined variable.

Generally, the results suggest that teachers that perceive their students' attitudes in the S&T classroom as positive and have no prejudices about scientists or negative opinions about S&T tend to perceive no gender differences in students' attitudes toward S&T learning.

B. Interviews

1. Demographics

The qualitative analyses were conducted on interview data from ten survey respondents that had indicated their willingness to be interviewed. This sub-sample consisted of seven female (70%) and three male teachers (30%), which corresponds approximately with the overall gender ratio of study participants (74% female and 26% male). Five interviewees (50%) were between 51-65 years old, three participants (30%) were between the ages of 31 and 40 (overall: 40%); and two interviewees (20%) were between 24 and 30 years old, which is a similar percentage in comparison to the overall (24%). Further demographic details can be seen in Table 20.

Table 20

Subject[1]	Gender	Age[2]	Educational Background		Teaching experience[2]	
			High school[3]	University	General	S&T
Amy	female	51	B:13;C:13;P:10;M:11	BEd	10	3
Joan	female	61	B:12;C:11;P:11;M:13	BEd; BA	31	31
Katy	female	31	B:13;C:13;P:13;M:13	BEd; BSc	8	6
Liz	female	58	B:13;C:12;P:11;M:12	BEd**;BA	25	20
Mary	female	40	B:13;C:13;P:13;M:13	BEd;	18	14
Mike	male	52	B:13;C:13;P:13;M:13	BEd; BSc	15	7
Ray	male	38	B:13;C:13;P:13;M:13	BEd; HBA*	4	2
Rose	female	54	B:13;C:12;P:11;M:12	BEd; MEd	16	11
Tom	male	29	B:13;C:13;P:13;M:13	BEd; BSc	4	4
Zoe	female	27	B:11;C:10;P:10;M:12	BEd	3	3

[1]pseudonyms; [2]years; [3]academic level achieved in biology (B), chemistry (C), physics (P), and mathematics (M); *Honours Bachelor of Arts; **Windsor's Teacher's College (predecessor of the Faculty of Education, University of Windsor, trained students to teach in the elementary schools of Ontario; founded in 1962, closed in 1970)

2. Qualitative Analyses

The most noteworthy quantitative finding was that teachers who perceive their students' attitudes in the S&T classroom as positive and have no negative preconceptions about scientists/engineers or the scientific/technological field tend to observe no gender differences in students' attitudes toward S&T learning.

This outcome is based on six positive relationships found in this study. The variable teachers' *perceptions of students' attitudes toward S&T learning* was significantly correlated with teachers' *attitudes to S&T teaching*, teachers' *knowledge of and interest in S&T issues*, and teachers' *perceptions of gender differences in students' attitude to S&T learning*. Additionally, a significant positive relationship between the variable teachers' *knowledge of and interest in S&T issues* and both their *attitudes to S&T teaching* as well as their *perceptions of gender differences in students' attitude to S&T learning* was found. Furthermore, the multiple regression analysis of the dependent variable *gender differences in students' attitude to S&T* with the combined variable *beliefs regarding scientists and S&T / students' attitude to S&T* revealed a significant linear relationship that allows good prediction of both independent variables. The variable teachers' *attitudes to S&T teaching*, however, was not significantly correlated to their *beliefs regarding scientists and S&T.*

To explore possible explanations for these outcomes, ten interviews with female and male teachers between the ages of 27 and 61 were analyzed. The analyses of the qualitative data focused on the three main research questions delineated in chapter I (page 10) and below.

Question 1: What is the strength of the relationship between teachers' attitudes toward S&T teaching and their perceptions of students' attitudes to S&T learning?

In order to explain the positive relationship between teachers' attitudes to S&T teaching and their perceptions of students' attitudes toward S&T learning as revealed by the quantitative data analyses, the interviewees were asked different questions that focused on these themes. In particular, the answer to the question "Would you choose to teach S&T if you had the choice or would you prefer to teach another subject?" (#18) as well as to the questions that focus on the educators' approach to S&T teaching (#s1, 2, and 3; Appendix B) were scrutinized to learn more about the teachers' feelings and opinions about S&T teaching and to unravel possible associations with their perceptions of students in the S&T classroom. The responses to those questions were then primarily compared with the answers given to question #5 "Could you offer your point of view about your students' attitudes toward, and perceptions of S&T?" and question #6 "In your opinion, why do students have these perceptions?"

<u>Teachers' attitudes toward S&T teaching</u>

The majority of interviewees exhibited a positive or very positive attitude toward S&T teaching. In responding to question #18, five interviewees accented their enjoyment of teaching S&T and said that they would definitely choose S&T as their primary teachable; three teachers admitted that they like teaching S&T but would enjoy teaching a different subject more; and two interviewees were not content with teaching S&T, whereas one would rather teach a different subject altogether and the second one did not enjoy it because of the particular situation at his school (lack of resources, low expectations from school administration, disengagement of students due to lack of encouragement from home/low socio-economic background).

Tom, a 29 year old teacher who brought with him a substantial science background due to a bachelor's degree in that area (BSc), had no intention to switch his teachable subject and simply declared: "I enjoy teaching the sciences."

Likewise, Katy, who is two years older than Tom, has two more years of S&T teaching experience at the middle school level, and also obtained a BSc declared: "I like science….It's fun. It's a challenge." The challenging and also most enjoyable part, she further explains, is the teaching itself, the "break[ing] it into pieces [so] that students can digest it". When contemplating about her study experiences in the sciences, she explained: "I've always enjoyed science but I've always just known that I will be a teacher. So I would take the sciences and teach it."

However, it is partially difficult to categorize teachers' attitudes to S&T teaching into positive or negative since some interviewees were not consistent in their descriptions of their classroom experiences particularly after probing for clarity. Liz, for instance, a 58-year old female teacher who could look back on 25 years of general and 20 years of S&T teaching experiences, expressed a very positive attitude toward S&T teaching by declaring: "I like science, I enjoy science, I like reading about science". When asked whether she would choose to teach science or another subject, she sighed heavily before contemplating: "I wouldn't avoid it, it's not, you know, it's not something I would avoid teaching, no" and after further probing she disclosed: "No, I probably wouldn't teach science, well… I probably wouldn't." Another example is Ray, a 38-year old male teacher who brought with him a sufficient math and science background from high school besides several years of work experience in business before starting to teach S&T four years ago. Ray's overall attitude toward S&T teaching was rather negative but when asked about his preferred teaching subject, he expressed his enjoyment of S&T teaching by revealing: "…my preference is history but my second would be science. I enjoy that, I enjoy it, I like it. I mean science competitions this year: I don't know who had more fun, me or the kids, you know? I like it; it's fun."

Teachers' perceptions of students' attitudes toward S&T learning

Six of the ten teachers reported that the majority of their students enjoy S&T learning; two interviewees thought that some of their students like S&T while other students dislike it; and two other teachers had the impression that most students have aversions to S&T.

No matter how the interviewees perceived their students, the majority of them were careful not to generalize and highlighted that students' attitudes toward S&T may vary from topic to topic, from class to class, or from individual to individual. In their responses to questions five and six, none of the participants mentioned gender differences between those individuals.

Zoe, a young female teacher with three years of S&T teaching experience delineated the relationship between students' positive attitudes toward S&T learning and the topic she teaches: "when I do something really interesting with them, I can tell that ….a lot of them are interested in science and get excited about science."

Tom, who rotated as a science teacher between two and four different classes and grades every year, observed significant attitude differences between different grades some years: "The four's were a lot more into it…., they were all there, and they wanted to do it all. The higher grades, I found there were only a handful of people interested." In other years, however, he found that the differences in students' attitudes to learn S&T varied more between classes than grades: "[I] wouldn't attribute it as much to the age, but the specific group of kids….I had some kids that were really into it, and really interested, and having fun with it, and then I had some kids that really didn't care."

The possible relationship between students' attitudes to S&T and their age has also been described by a couple of other interviewees. Mike, for example, a teacher in his early fifties who had high expectations due to positive teaching experiences gained abroad, explained: "I don't see high [interest] in general, at this aged individuals, um, they probably perceive it as pretty boring, and [I think] also difficult."

Additionally, four of the educators that perceived the attitudes of most of their students' as positive or somewhat positive emphasized that the attitudes of a number of students had shifted from negative to positive between the beginning and the end of a school year, while those teachers that perceived their students' attitude as more negative believed that in most cases this negative attitude does not change to a more positive one over the course of the school year. Not a single teacher reported an attitude shift from positive to negative. The assumed reasons for the change in students' attitude, though, differed: some educators mentioned that a number of students disliked S&T at first because they thought S&T is boring and they could not see how what has been taught relates to them. As Joan described it: "….the [students] get interested when you have hands-on activities and then, they learn how important S&T in everyday life is, so then they change their attitudes." Other teachers attributed students' anxiety about S&T to the excessive demand experienced at an earlier point in school. Mary, a 40-year old female teacher with 14 years of S&T teaching experience, explained: “Well, if you have a teacher that says ok we have to get all this done, and it’s like push, push, push… they are going to find that it is way too far based on their expectations, I guess. [And] when I had the students that were quite terrified of the science, because it is academic, if you continue to use that exploratory stage, if you continue to let them know that it is not so much the end results of the process, and how they go about doing that, then they tend to like it a lot more.”

However, when comparing the answers regarding students’ attitude and the actual teaching, it seems as if the topic or unit that has been taught is of lesser importance than the method used. The majority of the teachers, including one of the two that predominantly observed negative attitudes in most of their students, specified as the main reason for students’ positive response to S&T that they, above all, enjoy hands-on and other activities they can actively partake in.

Joan, the female teacher that has built up substantial knowledge in 31 years of S&T teaching in various classes from kindergarten to grade six, said: “I try to make it as hands-on as possible because that way all the children can be involved and even the children who are very reluctant in that area [ ] will go in and work on it.”

Relationship between teachers’ attitude and their perceptions of students

In their response to the question regarding their favourite teaching subject (#18; see above and Appendix B), seven of the ten interviewees knowingly or unknowingly cited students as the primary factor associated with their emotions regarding S&T teaching. Interestingly, in all seven cases the participants associated a primarily positive teaching experience with their students. Joan, for example, a very experienced female teacher who was close to retirement said: “I have to say that when you really get right into [a certain unit] and the kids get into it, and they like it, than I like it.” Joan further offers a possible explanation for her positive attitude toward S&T teaching while describing the interconnection between her enjoyment of teaching certain science-related topics and students’ attitudes toward the learning of these areas:

“Because I know that area [e.g., weather], and I really enjoy it; you have to get [the students] to the point where they enjoy it, and you have to enjoy teaching the course; they ask questions constantly and they want to know how everything works; [] I just love that when a child does that. When their hands are up constantly asking questions, I really enjoy that.”

Similarly, Zoe, mentioned students’ enthusiasm as the main reason for her positive attitude toward S&T teaching: “I would definitely choose to teach science as one of my top subjects because I feel that students can get really excited about learning it.”

The three teachers that did not refer to students in their response to question #18, however, mentioned them at another point in the interview. When asked about their approach to S&T teaching and the factors that they consider most important in teaching this subject, all three educators not only talked about their students, they did so in a way that portrayed most of them as either apprehensive, unable, or unwilling to learn S&T. Ray, for example, the teacher with work experiences gained in business and who seemed to be rather frustrated about his students’ performance and attitude, stated:

“…from what I have learned, it is only about twenty percent of students that really care, and really want to be there, and really want to learn, especially in science“, and while further explaining his teaching approach in S&T: “but the students need to realize that they are there to learn, and it is not social hour.”

Similarly, Mike, a teacher with a BSc who teaches at a compensatory school, explained: “I would do demonstrations; not a lot of hands-on stuff for the kids because the kids don’t seem to be able to handle it very well. Not what I necessarily want to do, but that is the situation that I have to follow.”

Mike and Ray are educators who demonstrated an overall attitude to S&T teaching that was relatively negative and who followed a very structured, classical approach to S&T teaching with few hands-on activities. Slightly different from those two teachers’ approaches was Amy’s, the third educator who did not mention students while talking about her most favourite teaching subject. Although Amy’s preferred teachable was not S&T, this educator seemed to be less discouraged by students’ attitudes than Mike and Ray. Amy, who is about the same age as Mike and who, like Mike and Ray, worked in another area before becoming a teacher a couple of years ago, tried to increase the ‘enjoyment factor’ of her students, which is the contrary to Mike and Ray. Amy incorporated as many hands-on activities as possible in her teaching because “kids love doing [hands-on] experiments” and because “putting a bunch of notes on the board [is] boring”.

However, when asked about her teaching objectives, Amy put emphasis on the importance for students to learn and understand the concepts, similarly to Mike and Ray. Three more teachers besides Amy, Mike and Ray expressed the opinion that teaching the students the concepts and focusing on the content is most imperative in teaching S&T; three other educators thought that it is most important for the students to be able to relate the S&T content to everyday context; and one of the ten teachers emphasized the importance of students' enjoyment in learning S&T.

Liz, the teacher that explicitly expressed the belief that students' enjoyment is more vital than their understanding of the content, also reported that students who were hesitant at the beginning of the school year changed their attitude when they had fun in the S&T classroom: "…if they have a good experience with [science] in the classroom, they really like it… I see kids going out of my room really liking science, honestly they do."

Katy, who always uses a combination of practice and theory in her S&T teaching, gave an account of similar experiences: "It is not the subject itself; it is more when we are not doing fun things that they [do not like S&T]."

To ensure that the learning experience is as positive as possible for most students, including those who do not like to read and write, both teachers put emphasis on hands-on activities in their teaching approach. Three other interviewees spoke about hands-on activities as their preferred teaching tool, while four interviewees believed that hands-on activities are as important as other procedures in the S&T classroom, and one teacher reported that other tasks are more important than hands-on activities.

In short, a predominantly positive attitude to S&T teaching and mainly positive perception of students' attitudes toward the learning of S&T was depicted by the majority of interviewees. The relationship between teachers' attitude and their perception of students' attitude to S&T was strikingly positive as has been shown in examples of educators with a predominantly positive attitude, and those with a primarily negative attitude toward S&T teaching. It is important to note that most of those teachers that reported positive attitudes to S&T learning in the majority of their students observed an attitude shift from apprehensive or dismissive to positive in some students. Teachers that did not describe this shift showed a predominantly negative attitude toward S&T teaching. Moreover, although only one interviewee openly expressed the opinion that it is more important for students to have fun in the classroom than to learn the concepts in S&T, all teachers stressed the importance of doing as much hands-on activities as possible in order to reach as many students as possible.

Question 2: To what extent do teachers' attitudes to S&T teaching relate to their comfort level in the S&T classroom?

The findings of the qualitative analysis informed by the answers to this question will be used to explain the positive relationship between teachers' attitudes to S&T teaching and their knowledge of certain S&T issues as revealed by the analysis of the quantitative data.

A teacher's comfort level, as defined in the 'definition of terms' (see CHAPTER I B), is a mental construct and, therefore, difficult to decipher by quantitative means. Teachers' comfort levels in teaching a certain subject, however, are to a substantial degree linked to their confidence in teaching that subject, which can be examined by their knowledge of the subject and their experiences in teaching it. The variables *educational background* (high school courses taken, university degree) and *years of general and S&T teaching*, therefore, will be used to estimate the degree of the participants' knowledge and experience. To further examine teachers' comfort level in teaching S&T, their self-confidence and self-esteem will be elucidated and compared with their knowledge/experience-based confidence. In order to investigate teachers' degree of self-confidence, or the extent of confidence they have in themselves when considering their teaching capabilities, the interviewees were asked: "How do you rate yourself in regards to your confidence and competence to teach S&T, using a scale of one to five?"

The examination of teachers' comfort level also incorporates the exploration of the phenomenon self-esteem, which will be accomplished by dissecting the interviewees' descriptions of how they feel about their S&T teaching and what their experiences in the S&T classroom were. Finally, the association between teachers' comfort levels in teaching S&T and their attitudes toward S&T teaching will be investigated.

Generally, all interviewees were confident in teaching S&T and more than half of them were extremely confident. Using a scale of one to five, one teacher chose the highest rate of five, another one said her confidence level is between four and five, five educators rated themselves a four, and two teachers rated their level of confidence between three and four. One interviewee did not rate herself but was as confident as those teachers that chose three to four as their confidence level. No participant rated her-/himself below a confidence level of three to four.

However, the data revealed that knowledge-based restrictions apply in four cases: Three teachers said that they are confident with teaching S&T in grade 6 and lower grades but that their confidence level, which varied between three to four and four, would be lower if they were asked to teach higher grades than they have been in the past; one teacher explained that she feels very confident in teaching certain S&T topics but not in others. The latter educator rated her confidence level a five.

Confidence with restrictions

Four teachers reported that their confidence in teaching S&T is restricted by their knowledge. Joan said that she does not feel overly comfortable with teaching topics she does not have substantial knowledge of, while Liz, Amy and Zoe stated that their confidence is limited to what is taught in classes up to grade six. These educators' confidence, therefore, is restricted to the units of the elementary school S&T curriculum they know and have teaching experiences in. However, those four teachers seemingly did not internalize a lack of self-confidence due to this restriction since they rated their confidence level five, four, or three to four.

Joan, the senior teacher with 31 years of teaching experience and a strong high school mathematics background rated herself five on the confidence scale. Her strong confidence level, however, was not linked to her mathematics background from high school, but was likely due to those science subjects she took additional university courses in: "….teaching weather, and teaching the human body, I would say [my confidence level is a] five; [in regards to teaching] 'forces on structures' - I would go down to about a two, [which] is why they are trying to get another science teacher that could teach that section, because I don't feel competent in it. What I teach, I want to teach properly and I want to make sure that the children actually enjoy it."

Similarly conscious about her strengths and weaknesses in S&T teaching was Liz, a very experienced educator with 25 years of general and 20 years of S&T teaching experience, who reported that she has never taught a higher grade than 6. When asked about her confidence level in teaching S&T, she rated herself four out of five but admitted that this depends on the grade level: "Grade 7 and 8, some of those things, I wouldn't feel confident with, but I think anything up to grade 6 I feel pretty competent with." Interestingly, after probing for explanation she substantiated her judgment with a strong knowledge base and her experiences in the S&T classroom, which seemingly were neither overly negative nor positive: "I have enough factual knowledge [and] kids don't usually stump me on things." Liz obtained a bachelor's degree in geography and took grade 13 biology, grade 12 chemistry and mathematics, and grade 12 physics in high school.

Zoe, the second teacher in this group who rated her confidence level a four, saw her limitation, like Liz, in the curriculum solely. However, Zoe's educational background in the sciences was weaker than Liz', with only introductory high school knowledge in chemistry as well as physics and an understanding of biology that derived from grade 11. Despite the fact that this teacher was, with 27 years of age, the youngest of all participants and, with three years of general as well as S&T teaching experience, one of the less-experienced educators, she demonstrated a high degree of self-esteem and self-confidence in the interview. Zoe strongly believed in her teaching abilities, which can be seen in the way she admitted that she has to prepare for each S&T class: "So I am really confident but I do have to take the time to read over the material the night before to make sure that I have a solid grasp on it before I actually present it. So, I am fairly confident but that is mostly because I prepare myself."

Amy, another educator that mentioned a limitation regarding confidence in her statement, was the only teacher in this group that rated her confidence a three to four. Her lower degree of confidence might be related to her educational background from high school – although she attained grade 13 in biology and chemistry, the fact that she never liked math and did not take any physics courses in high school might have been an obstacle for her, at least in regards to teaching higher grades: “Um, (pause) for grade four I’d say a three or four; if you put me in grade 7 or 8, I’d be a little bit more worried. But yeah, I’d probably say a four, I mean, it’s a pretty simple concept…about twelve years ago, that was my first year teaching, [I] definitely improved since then…. So, um, yeah I’d say I probably started out ….two-three, and I’m yeah, I’d say a three-four.” Amy was a very assiduous and reflective teacher who had high expectations of her teaching, which is probably why she was more critical of her teaching performance and rated her confidence level lower than the majority of the interviewees.

Confidence without restrictions

Six teachers did not mention any restrictions when rating their confidence in teaching S&T. Their confidence level ranged from ‘three to four’ to ‘four to five’ and they all had S&T teaching experiences in grade eight or above. All teachers in this group achieved high levels of secondary school science education: they all completed grade 13 biology, five completed grade 13 chemistry, four completed grade 13 physics and mathematics, and two teachers completed the advanced levels of grade 12 chemistry and mathematics as well as grade 11 physics.

The four teachers in this group that rated their confidence level either a four or between a four and a five, achieved considerable science knowledge at the university level: three obtained a B.Sc. and one achieved a minor in biology. The two teachers in this group that rated their confidence level between a three and a four obtained other qualifications: one graduated with a master’s degree in education and the other completed undergraduate courses in biology, calculus, and economics.

The four teachers with the higher confidence level supported their confidence with their science knowledge based on their educational background and/or other related experiences. Mike, who gained additional experiences from working in the industry and from teaching abroad, explained: “As I said earlier, I have degrees [in] biology and geology, which includes chemistry and physics; I have worked in the industry, so I have actually applied what I have done out in the world. I try to keep up with things, I do not read home quarter journals, but I know what’s going on in America, I look at Science online and stuff like that.”

Mary, the teacher that obtained a minor in the sciences and a major in human kinetics, reported that her knowledge gained from high school and university is sufficient for teaching S&T up to grade ten. “I know that I was teaching probably ten years out of high school and university, and the science curriculum and the expectations were very much the same [as what I learned] and I was lucky because I was able to have those courses and I have the background in it.” Besides a high level of confidence, Mary demonstrated a strong sense of self-esteem throughout the interview:

“So, in my experience my students were really good, they did well, and a lot of students went on. So I have medical doctors and some in the medical field, and going science-based, which is good, and a lot of females at that. There were several that I kept in contact with that were very good in my science programs….I mean if they had a terrible experience in the grade eight, maybe they wouldn’t have. But I think I kind of pushed them toward it and said, of course, they had a good experience they must have to continue in that.”

Similarly, Katy, the 31-year old speciality science teacher demonstrated strong self-esteem and expressed her love for teaching S&T by choosing to become a science teacher instead of continuing her university degree in biology. She explained that she does not bother to put a lot of effort into class preparations since she teaches three to four grade seven and eight classes per year. “So, I would take the sciences and teach it.” Katy further admitted: “I am not the kind of person that watches the discovery channel or that reads journals – maybe I would if I taught older kids? But I teach younger kids and we go for the basics.” It is noteworthy that the ‘basics’ Katy teaches are the scientific concepts that four of the interviewees tried to avoid because they did not feel sufficiently competent to teach them in grades seven and eight.

The two teachers in this group that rated their confidence level between a three and a four both seemed to be fairly confident in teaching S&T at the elementary level. However, in their interviews both exhibited a touch of uncertainty that might affect their comfort level. This feeling of uncertainty might derive from a lack of university-level S&T knowledge, as in Rose’s case, or from an overall lack of confidence in teaching, as in Ray’s case. Ray had only four years of teaching experience when he started working as a teacher at the age of 34, and his teaching experiences were not overly positive since he taught students who had many issues that made S&T teaching not as rewarding as he had anticipated.

Despite Rose’s assertion that she is a good S&T teacher, the way she underscored her scientific knowledge and talked about her confidence level suggests that she was not as confident in teaching S&T as she claimed:

"I think I am a good science and technology teacher; I know that from the feedback that I get from the students, [and] also [from the] things that I hear [from others]….I mean I have a lot of science knowledge, and I think I am fairly confident as a teacher…I am not one of those people who are afraid of science, and I have never been afraid of science."

The fact that Rose repeatedly used the term 'I think', that she seemingly relied on the positive feedback of students and other people to feel good about her S&T teaching, that she had to distance herself from people who are afraid of science, and reassured herself that she has never been afraid of science could be seen as an indication that her comfort level in the S&T classroom is not as high as she claimed.

In summary, all interviewees were confident in teaching S&T (level 3.5 to 5 out of 5) and more than half of them were very confident (level 4 and higher). Their confidence level was mainly based on their degree of S&T knowledge, which could be seen from the fact that the four participants who rated their confidence level the highest also had the highest degree of education in S&T. Four participants, who rated their confidence level fairly high, mentioned that their comfort level is restricted to teaching the grades they gained S&T teaching experience in, which was grade 6 or lower. The comfort levels of two participants that did not restrict their confidence to any grades was seemingly lower because of uncertainty due to either lack of higher degree S&T knowledge or lack of confidence in teaching overall.

Question 3: How do teachers' perceptions of students' attitudes to S&T learning relate to their perceptions of gender differences in students' attitudes and are those perceptions related to teachers' beliefs and opinions of scientists and S&T?

The quantitative analysis revealed a positive correlation between the variable, *teachers' perceptions of gender differences in students' attitudes to S&T learning*, and the variable, *teachers' perceptions of students' attitudes to S&T learning*, as well as with the combined variable, *teachers' perceptions of students' attitudes to S&T learning / teachers' beliefs regarding scientists and S&T*.

In the following section of the qualitative analysis, focus will be laid on probable gender bias toward students as well as scientists that might influence the interviewees' S&T teaching. In particular, the association between teachers' perceptions of gender differences in students' attitudes toward S& T learning and the educators' beliefs and opinions of scientists will be explored. Several questions (questions #7-10; see Appendix B) were posed that allowed an exploration of the interviewees' perceptions of gender differences in students' self-perceptions, attitudes and approaches to, as well as abilities in learning S&T. Furthermore, the teachers were asked to disclose their opinion about possible differences in the way female and male scientists are seen and whether they believe female scientists might face more or other obstacles than male scientists in the workplace (questions #12-15; see Appendix B). Additionally, the interviewees were forthrightly asked whether they think that their image of a scientist is biased (question #16; see Appendix B) and how they prevent any stereotypical or biased thinking from influencing their S&T teaching (question #17; see Appendix B). Finally, the participants were asked to elaborate on the question whether they think they treat female and male students in the S&T classroom equally (question #11; see Appendix B).

Perceived gender differences in students

All ten interviewees reported that they observed gender differences in their students' attitudes to S&T and stated that they believe these differences are not caused by intrinsic cognitive abilities. Not as distinctive were the statements when the teachers were asked about perceived differences in female and male students' approaches to S&T learning: eight educators observed gender differences; one teacher spoke about gender differences that were much more pronounced about ten years ago, and one educator did not answer the question concerning gender differences in students' approach to S&T since he thought that could not be done in a fair and objective way.

Gender differences in students' attitudes, abilities, and approaches

The prevalent differences reported were that most boys (a) like hands-on activities more than girls; (b) are more active in the S&T classroom than girls; and (c) take more risks than girls particularly when it comes to participation in science-related discussions. The majority of girls, on the other hand, like more, and do better in, sedentary tasks that involve reading and writing than boys. However, some of the reported gender differences are not science-specific, as emphasized by two of the ten interviewees.

Included among teachers' responses that purports the non-science specific gender differences is that of Zoe, the youngest of the interviewees, who observed that girls were just a little bit more attentive and more willing to do paper-and-pencil type of tasks in contrast to boys that preferred other tasks. Noteworthy is this teacher's assumption that boys' inclination to hands-on activities might be their innate way of learning: "It was more the hands-on aspect to [S&T learning] that the boys really got into it. I think that just might be the nature of how they learn." Immediately after this statement, Zoe realized that this might be a generalization she perhaps should not make, but she did not correct it. When asked about the probable reasons for boys choosing a different approach to learning, Zoe answered cautiously while looking for clues in students' behaviour: "I don't know. I think it maybe is because boys are more active in general. Like at recess, the girls are playing quietly sitting and the boys are out playing soccer."

Being more active is, in Zoe's opinion, not only a different approach to learning, it is also a sign of being more interested in the topic: "So, it just makes sense that when they [the students] are in the classroom to learn, the more active they are, the more engaged they are."

Interestingly, in the grade four class Zoe taught last year, she observed that more boys than girls showed interest in S&T, which she exemplified with their interest in the subject 'rocks and minerals': "I find that boys in the class are more interested in science. Not all of them but I had a handful of boys this past year that really got into the unit; they would bring things from home, fossils from home, books from home; my girls wouldn't do that; they still, ahm, participated and were interested in it but I think the boys just got a little bit more into it than the girls."

Similarly, Mary, a self-proclaimed "advocate for specifically females in science and technology", observed some differences and some similarities between girls and boys. Overall, she perceived boys as the gender that takes more risks and that is generally more 'kinaesthetic', more focused on muscle memory and hand-eye-coordination:

“In my experiences, my boys were very kinaesthetic. Kinaesthetic to the point where they wanted hands-on, and they liked the labs, but the girls tend to be strong, strong in, in that they wanted to get things done and, and they were able to do their write-up or that. But that doesn’t mean the girls didn’t like to do the hands-on either; I just found that the boys tended to like to get their hands in there, if they could.”

As could be seen in this statement, Mary considered girls as different from boys but made sure that the listener does not get the impression that she, Mary, views this gender difference as weakness by emphasizing that the girls are strong. However, this strength of girls is different from boys’ strength in the sense that girls are more organized and diligent than boys especially when it comes to writing and reporting. At another point in the interview, Mary further distinguished between the genders by explaining that girls’ learning approach to mathematics and science is more hesitant and often more ‘academic’ or theory-based than boys’ approach. The academic approach, however, was according to Mary rather based on females’ biological characteristics than on their social upbringing. In contrast to girls’ learning approach, this educator believed that boys’ braver approach to S&T is due to nurture and not nature.

However, Mary, just like Zoe, equated being more hands-on with being more engaged in S&T learning but went further in her analysis of her experiences than Zoe by stating that ‘kinaesthetic’ students are performing better in S&T:

“[ ] the students that weren’t doing well were the ones that didn’t know how to do an inquiry-based project. [These] were the ones that were reading from the textbook, [that were] more academic as opposed to physical. [] I have seen [students that had] a tough time, and they [had] a tough time [because] they viewed it as tough. I think [it is fun for other students, who] want to learn, [who] want to explore – and they get their hands dirty. [For them] it is like going back to kindergarten at the sink. If [students] realize that the sand table, the Lego, [or] the building blocks [are in fact] science-based projects, [] that [] if they were to go back to that [stage] and just being able to [see that the] answers [to a scientific problem] are there, they were ok. [But students that think] 'oh I'm not good enough, [] I'm not good in science', those are the ones that were going to have a tough time."

Students that choose a more academic approach to S&T learning, therefore, had a more difficult experience in the S&T classroom because of their negative attitudes that derived from students' own elevated expectations and the belief that the overall expectations are high due to the level of difficulty of the subject.

<u>Gender differences in students' self-esteem</u>

As shown in the previous section of the analysis, the vast majority of interviewees observed distinct gender differences in students' attitudes and approaches to S&T learning. The question that derives from these statements is how objective are their observations? To examine their objectivity concerning gender differences in their students, other gender-related questions were posed during the interview. Question number 10, for example, was posed to explore teachers' opinion about girls' self-esteem and to tease out their point of view in regards to possible reasons for this stance, which is regarded as speculative since it goes beyond the teachers' experiences in the S&T classroom. The question was as follows:

"Research suggests that fewer female than male students believe that they are sufficiently skilled in science at the beginning of high school. Have you seen similar tendencies in your science and technology classes and if so, in what grades? Further, do you have an idea about why this might be the case?"

Three interviewees agreed more or less with this statement, three disagreed with it, and four interviewees did not clearly say if they agree or disagree. Included among teachers' responses from the group that did neither fully agree nor disagree with the above statement was that of Joan, the oldest and most experienced interviewee, who believed that girls used to exhibit lower self-esteem but was convinced that this has changed:

"The females do seem to shy away from science a lot more, but not as much as they used to. A lot of girls are going into engineering areas and into that area, which they never used to, so you know, I don't think there is that much difference anymore than there used to be."

Even more hesitant but agreeing with the statement in question number 10 was Mike, who earlier in the interview refused to take a firm stand when asked whether he encountered gender differences in his S&T classroom by saying "It's hard to answer that question in any sort of fair, objective way." By distinguishing between his 'personal' (subjective) 'belief' and his seemingly objective observations, he tried to be as impartial as possible in his answer to the question whether he noticed lower self-esteem in girls, which seemingly caused some confusion:

"My personal belief, from what I have seen, I cannot say that that is true, but my personal belief is that it probably is… [true that] females [] have many of those skills. You still see the boys with the computers and stuff like that; [] a lot of them are pretty adept to those [things], whereas you don't see the same interest in girls. Probably in girls in terms of studies in computers; in girls, you still see that there is somewhat of a lower expectation in terms of what they can do [] versus [what] boys [can do]. So, my personal belief is that, yes, [more female than male students believe that they are not sufficiently skilled in science] but I can’t say that [this] is [accurate].”

In his response, Mike did not talk about lower self-esteem in girls explicitly. Instead, he used a rather positive term by talking about certain skills he believes girls have that derive from having lower expectations than boys for their achievements in S&T. From what Mike said somewhere else during the interview, by this he most likely meant girls’ low expectations for their future in general and not for their achievements in school solely. However, by making the distinction between his ‘personal belief’ and his observations, Mike attempted to convince the listener that he is always aware of his biases and, therefore, is capable of not letting his personal beliefs influence his teaching. That this is not the case became obvious in his response to question number 11. When asked whether he thinks that he treats boys and girls in his S&T classroom equally, Mike said yes but admitted that he does not reflect on his teaching enough to be certain if this is true:

“I would say yes. I probably like the females better in terms of the stronger students; the stronger students are females in my class, so maybe I treat the females, I expect more from them than the boys, but that is hard to say. I don’t sit around and on it too much, in terms of my own practice, so, I may or may not….I think that I try to pass it around, I don’t do anything in particular and I don’t reflect on it.”

Moreover, in his statement Mike sought the researcher’s agreement by expressing the possibility of having gender biases that would be in favour of female students, which might be more acceptable than if they were against females: “I don’t have a certain election for boys; …I don’t have that kind of thing [sports, buddy] with the boys; …I am not a guy’s guy.”

<u>Perceptions of the scientist</u>

In this part of the analysis the interview data that centered on bias toward scientists will be examined. In particular, the interview questions #12 to #15 that focus on perceptions of the scientist and the scientific/technological work environment of female scientists that teachers have as well as those perceptions teachers believe others might have will be analyzed. Additionally, question #16 and #17 will be scrutinized since the interviewees were asked to disclose whether they think their own perceptions of the scientist are biased or not, in which way their perceptions might be biased, and how the teachers prevent their biases from influencing their S&T teaching.

<u>Perceptions of stereotypes in society</u>

The interviews revealed that all ten participants were convinced that the stereotype of the scientist as primarily male still exists in society. Tom, for example, the young male teacher with a university education in the sciences, who believed that the scientific approach is gender-neutral and who, at the beginning of each new school year, explains to his students “that anyone and everyone can and is a scientist”, reported:

“I would say yeah [most people have a stereotypical image of the scientist]. They all probably picture the guy in the lab coat with the glasses, and all that stuff….Um, why? Maybe that is what they were brought up with, that is what their teachers were like, and, and that is what they see on TV, or in the movies or whatever, and that is the perception that they get.”

Perceptions of students' stereotypes

The majority of interviewees also observed prevalent stereotypical thinking in their students. For instance, Ray, a teacher in his late thirties, was flabbergasted by the stereotypical responses he got when he discussed gender roles with his students:

"I think a lot of girls do have a stereotype of what girls, what careers are girl careers, quote on quote, and what careers are boy careers. Engineering and science are boy careers." Ray further explained that he believes this is changing but later retracted his statement by saying that, no matter how much teachers "try to help [their] students break these stereotypes, these stereotypes still exist." And in a rather frustrated tone, Ray offered an explanation for why he, like any educator, cannot really change students' stereotypes:

"I honestly really believe that those attitudes are um, heavily influenced by the socio-economic [background] or the family that these girls grew up in.…because mom isn't going to help because she really doesn't care, or she does not have time to."

This statement, however, refers to the fact that Ray taught at a compensatory education (comp-ed) school that offers supplementary programs designed to help children at risk of cognitive impairment and low educational achievement reach their full potential. A substantial number of Ray's students live in low-income households with the mother being the single parent.

Perceptions of own stereotypes

The interview responses concerning the teachers' images of the scientist as well as their perceptions of their own biases toward scientists were multifaceted and partially ambiguous or contradictory due to the delicate matter. To unravel the complex issue of stereotyping, the following part of the analysis will focus on the exploration of four main questions: What were the participants' images of the scientist? Are the participants aware of their biases? How do the participants deal with their biases? What are the consequences for their teaching?

All the participants described the scientist in one way or another as a person that enquires, tries to 'figure things out', is curious, unbiased, and organized. An important part of this inquirer image was, for most of the participants, that this person does experimental work. Beyond being a good researcher, the scientist was described as somebody who is (a) "able to show others how what happens in the world works" (Joan); (b) "dedicated and passionate" about her/his work (Katy); (c) "highly creative" (Rose); (d) "good communicator in terms of writing" (Mike); and (e) "academic, strong, quirky, and well-rounded" (Mary). As can be seen in the latter image description, in which the scientist is a quirky and well-rounded person, the delineated characteristics are not always coherent.

Initially, only one participant allocated a gender to her description of the scientist. This participant, Zoe, who distinguished herself from many students that pictured the scientist as a man that looks as if he has "been electrocuted", admitted that she automatically, attached the male gender to her image of the scientist. To be more precise, Zoe, pictured David Suzuki, a more recent scientist that is very different from Albert Einstein but is also used by the media in a symbolic fashion.

After probing, Mike also admitted "the default would be a man" in his image of the scientist, despite his knowledge of the fact that more women work in the scientific field nowadays than ever before.

When asked whether he thinks he has gender biases about scientists, Mike, who usually responded to questions in a well thought, mature way, answered hesitantly, which can be seen by his repeated use of ‘you know’:

“…if I reflect on it I would say no [I have no gender bias] because [] I am from, you know, a university in science; I know people that are professors of science….if I think that, you know, women can be, you know, as good as scientists as men, of course they can be.”

When asked how he prevents any stereotypical or biased thinking from influencing his S&T teaching, Mike appeared puzzled, and stated:

“I don’t know that I do. Um, (long silence) did I, uh, really address it or think about it? I guess (Long silence) ‘cause, once again, in terms of time constraints, like, you know, I am here to teach this [S&T content]; so, I also have to think that I want to promote the female aspect. There are so many things you want to promote, like the fitness, and the character, and the gender, and the minorities, and everything else. There is so much… it’s overwhelming the number of things that they [the administration] want.”

Finally, he came back to the question regarding prevention of stereotypical or biased thinking from influencing his S&T teaching and reported that he does not try to prevent it consciously but that he believes in equal opportunities, meaning “that anybody can go to university, everybody can do this kind of thing.”

Four participants corroborated the ‘gender-neutrality’ of their image of the scientist during the course of the interview. Their stated opinions, though, differed in regards to the level of awareness of their own biases.

Included in this group is Tom, who knows scientists personally, has several female friends that are doctors or pharmacists, and who seemed to be oblivious of gender stereotypes since he has never paid attention to gender issues that possibly affect the readings and other materials he uses for S&T teaching. On the question whether he agrees or not with the statement that women and men in the scientific and technological fields are treated equally, Tom contemplated that "there is probably still alliance more toward the male side".

Similarly, Ray, who knows female scientists personally and who talked about the unfortunate fact that a glass ceiling still exists for women in those areas, also believed that gender is not an issue in the sciences. He, however, reported that he always reflects on his teaching and that he tries to teach students critical thinking and not to manipulate them in any way.

Katy, who is also convinced that the gender of a scientist is irrelevant for her or her work, is well aware of existing gender stereotypes in society as well as in the minds of her students, which is why she takes on a more active role when it comes to girls behaving according to these stereotypes: "They would act ridiculously [because of boys] and I would be like 'for what?' You are only twelve! Have some respect for yourself." However, concerning S&T teaching, Katy reported that she always treats female and male students the same way.

Joan, the teacher with the most extensive teaching experiences in this group of participants that did not attach a gender to their image of the scientist, highlighted several times during the interview that a lot has changed regarding gender stereotypes of scientists: “I think that most people are starting to realize that it doesn’t matter what gender you are.”

While the assertions of those four participants were rather comprehensible, the statements of four other participants concerning the gender-neutrality of the scientist were not as convincing after probing.

Included among participants’ responses from the ‘non-convincing gender-neutral’ group is that of Amy, a critical and reflective teacher who frequently uses gender-related material in her class to bring contributions of female scientists/engineers to students’ attention. Amy contemplated about her own stereotypes when asked to share her perceptions of the scientist: “I am wondering if I do have any stereotypes; for someone in my age group – [yes].” Amy further explained that she has “learned that scientists were men” when she grew up and admitted that, because of the stereotypes she was confronted with as a young person, all her doctors are male although female doctors are available. However, Amy distinguished between her own upbringing and the way she educates students as well as her own daughter, from whom she has always tried to dispel stereotypical thinking. When asked whether she believes that women who pursue a career in science or engineering encounter more obstacles than men, Amy agreed:

“…at the university level, there is still the old guard, the old foggy men that, you know, women can’t do that, they should stay home barefoot and pregnant. I mean that kind of garbage. Yeah, I’m sure they still do [face more obstacles]. Yeah, the glass ceiling, whatever you want to call it. Like its ok if they want to go into nursing, like that’s ok, that’s one of the softer sciences, but yeah, if they want to become a nuclear physicist – it’s like what’s wrong with you?”

With this statement, Amy confirmed her stereotype of the scientist, of which she is well aware and that she consciously tries to tackle in the S&T classroom: “I don’t want anybody [to say] I can’t do that ‘cause I’m a girl. That just drives me nuts. No! If you want it, you go for it.”

Another example is Liz, a teacher that was a young adult in the 1960s, who was convinced that her image of the scientist is gender-neutral but who, after probing, expressed gender stereotypes while talking about the people that work in different scientific areas. When asked whether she attaches a gender to her image of the scientist or not, Liz stated that she does not. Her description of the scientist, though, was that of somebody with preferences in her/his approach to S&T that are similar to those this teacher attached to male students: “a scientist has to really want to get down and dirty and right into it.” Liz realized after she has been asked whether her image of the scientist includes people who do more theoretical work, who write and read a lot, that her image of the scientist is biased. After sighing deeply, she admitted:

“Maybe I don’t consider them to be a true scientist then, you know? ‘Cause anybody can do reading and writing and memorize facts.” Therefore, a person who prefers theoretical, sedentary work, who is better in reading, writing, and memorizing facts, a person that, according to this and most of the other participants, is more likely female than male, is not considered a ‘true scientist’. Liz then distinguished between different scientific fields that she related to a certain gender: “To me the [male] gender is leaned toward computer; … they are what we used to perceive as science geeks.” She further explained that the kind of science that has always interested her was performed by “real people”, by female scientists like Jane Goddall “who worked with animals and that kind of thing … as opposed to somebody, [who is] sitting behind some machine. I suppose I perceive them as being [mostly] men."

Liz, however, was aware of her own gender bias and consciously tried to prevent any biases from influencing her teaching. When asked whether she thinks that her perceptions of a scientist are biased, Liz replied almost apologetic:

"I guess everybody has their own biases don't they?" She further contemplated the question by reflecting on how she would feel if she were to meet with a scientist she earlier called 'a true scientist': "I guess, I would, yeah, you know, I would think to myself if I had […] carry on a conversation with a chemist or a physicist, if I were, you know, sitting across the table from one and I had to talk for two hours, I would go 'eek, I wonder what are we going to talk about'."

The description Liz gave of an imaginary meeting with a chemist or physicist sounded more like an interview or interrogation in which she was in the weaker or dependent position than a conversation between two equals. However, Liz' apprehension about chemists or physicists derives from old prejudices about scientists as being uninteresting or not sociable. These views are not associated with experiences she probably gained within the last ten or more years since she has a daughter who "did physics" and an acquaintance that "is one of the head chemists [in a company] and he is a pretty cool guy."

<u>Gender bias toward scientists versus gender of students</u>

To further explore the relationship between teachers' gender bias toward scientists and their perceptions of gender differences in students, the participants' answers to question number 11 ("Would you say that you treat boys and girls in your S&T class equally? How do you know this?") are compared with the responses they gave concerning their gender bias toward scientists.

All participants re-affirmed that they try to treat girls and boys equally. Six participants demonstrated awareness of the fact that they might not treat both genders in exactly the same manner, three participants were convinced that they treat female and male students in the S&T classroom equally at all times, and one participant did not explicitly talk about equal treatment of students but responded in a way that could be interpreted as lack of awareness of own biased behaviour.

Awareness of unequal treatment

Rose, Liz, Zoe, Amy, Mike, and Ray reported that, although they try to treat the students in their S&T class equally, they probably treat female and male students differently.

While Rose contemplated about the problems that somewhat naturally occur due to the fact that she is "a human being trying to deal with another human being", Liz and Zoe admitted that they might subconsciously favour male students. The expressed assumptions why this might be the case, though, differed. Liz assumed that her teaching approach in S&T might cause gender disparities since she does "even more hands-on things, less reading and writing kind of things" when she has a class that is predominantly male, while Zoe thought that she probably calls on male students more often:

"What I think, though, is, because I know my boys are more engaged in science, I might subconsciously call on them more when they offer an answer. Because if Joe is never participating in language and all of a sudden we are doing science and he has all the answers and he is confident and he wants to tell me the answer, I'm going to be more likely to pick him then a girl who succeeds in other subjects."

Amy, Mike, and Ray, in contrast, believed that they sometimes deliberately favour female students. Amy, for instance, stated:

"I would almost say that I go the opposite end, and…with bringing in things about women scientists, I kind of load it the other way…and make it less gender-biased, than, perhaps, than it traditionally has been."

Similarly, Mike and Ray, often perceive boys as more defiant than girls and want to help girls more so that they succeed in school and have better chances in life than the generation of their mothers. Ray, after reporting that he uses differentiated instruction methods to promote learning in both genders, explained:

"I actually tend to try to help girls a little more because I'm a father of a daughter; I grew up in a family where I only had sisters. Because….I have seen people sell themselves short, I have seen a lot of girls that I went to school with sell themselves short and never achieve what they could have achieved."

<u>Equal treatment at all times</u>

Joan, Katy, and Tom explained that they treat girls and boys equally in every teaching-related aspect and all the time. The examples they used to corroborate their statements were that they (a) give female and male students the same assignments and questions; (b) group them together for activities and assignments; and (c) help every student that is in need regardless of her or his gender. That these measures might be insufficient in ensuring fully that female and male students have equal opportunities in learning S&T and could mislead the teachers over their own gender biases can be seen in

Katy's statement. Katy, who is one of the teachers that said she provides help to female and male students alike, explained that her attention in S&T teaching focuses on the means and not so much on the ends. That is, "whether or not they (the students) are trying and working" and not so much whether a written assignment, for instance, is as complete and comprehensive as possible. The way this teacher evaluates the "trying and working", though, seems to be gender-biased since it favours students that perform well in class orally, who are more often male students than female students.

As Katy explained further, the assessment of students in S&T is almost exclusively based on their performance in tests and written assignments but occasionally she might take a student's participation in class into consideration. Thus, when she has a student that does poorly on tests but shows otherwise a lot of interest in S&T by participating a lot in class, she would "bump [the grade] up a little bit" since this is perhaps an indication that "they (the students) get a little bit more than what they are showing me [in the tests]." Katy further explained how she tries to be fair in her assessment: "But it doesn't work the other way around. I would not bump it down because they (the students) don't talk as much. So, they (the students) are just different."

Katy did not differentiate between female and male students here but gave an example for how she would help students who have difficulties with writing, and these are mostly boys as Katy delineated somewhere else, while elucidating that she would only encourage girls to participate more in class if "I saw that they (the girls) are not learning." Katy further explained why she believes that most girls do not need extra encouragement:

"But sometimes kids are like that – sometimes they just want to hear it….I was like that way. I didn't like to give an answer unless it was right. So it meant that I was listening, no matter if my answer was right or wrong; if no one else would ask the question, I would ask. But sometimes kids can still learn; they only have a different personality. One would rather listen than talk."

The fact that Katy conveys her own behaviour as a student to the female students in her S&T class and inadvertently treats girls and boys differently could, therefore, be interpreted as an indication of gender bias.

Another teacher who was not aware of the fact that how she grew up, the way she has been socialized, generated gender bias that inadvertently influences her teaching, is Mary. Mary has always tried to bring the 'female cause' in the forefront by working in school administration while, during her active teaching years, gave preference to a S&T teaching approach that has been beneficial for her and helped her in becoming a successful professional in a male dominated area. This approach, however, is advantageous to more male students than female students, as delineated by Mary:

"You know research shows that there are males that are a lot more, predominately kinaesthetic, hands-on learners but that doesn't mean that females aren't either. I am a very kinaesthetic person, and it is based not so much on gender but on the learning style."

Mary then continued with what seems to be an attempt to explain the gender differences between females and males she observed in the classroom but the way she talked about tomboys could be interpreted as her talking about her own experiences as a kinaesthetic female student, who did not fit in the gender role society imposes on females:

"However, we tend to let the boys take the ropes; you know 'boys will be boys'. And I think once you think of that risk taking, and being able to get your hands dirty and that, I think here is still that difference. Not saying that there are not girls that are like that as well. Girls tend to be the ones that are more […] well-rounded; and they are not just the tomboys. I just think that there is still that gap there."

Mary's awareness of the existing gender gap might be the result of a revelation she had earlier in her teaching career:

"My first year, I [sent] all four of my top male students [to the annual S&T competition], and they didn't do very well; they were […] very strong, they couldn't get much done because they all wanted to be the leaders. So I learnt that. And now, I ended up taking the next one, the kinaesthetic ones, not so much risks [takers], they, um, [built] a great contraption, but they couldn't get anything down on paper. When I brought in females into the mix, um, and these particular females, and I had two and two, there was more the dynamics but the females tended to 'we have to get this done', and 'let's not squabble', 'cause there was time constraints, 'let's just do it', they, they brought in a different element to it, and then, they started to do better."

Mary highlighted that this success at a S&T competition "really had nothing to do with ability" but "with working together as a team", which, according to this teacher, is a skill female students share with scientists. However, Mary still seemed to be surprised about girls being as successful as or even more successful than boys at S&T competitions:

"That was a few years ago, so, and the winners, it actually was quite interesting because schools were putting in dual teams, all males and all females, and the females were going up against the males, and depending on those personalities, they were doing quite well (laughing) you know, a little bit of competition, and the females wanting to beat those boys, and there is nothing wrong with that either (still laughing)."

<u>Gender neutrality versus gender biases</u>

In the last section of the analysis, focus will be laid on the exploration of a possible relationship between teachers' gender-specific opinion about scientists and that about students. When comparing participants' statements in regards to equal treatment of female and male students with their responses concerning their gendered image of the scientist, a positive relationship becomes apparent.

Joan, Katy, and Tom, the three teachers who were convinced that their teaching is gender-neutral, for instance, also reported having no gender stereotypes of the scientist. Moreover, these three educators belonged to the group of participants that corroborated their assertion of gender-neutrality throughout the interview and showed no awareness of gender bias. The fourth participant of this group, Ray, however, was gender-biased in his treatment of students. Ray firmly believed in his gender neutral-image of the scientist but due to his personal experiences at home and with female peers at university who did not pursue a career and failed to live up to their potential, consciously supports female students in his S&T class more than male students.

The second teacher who expressed awareness of his tendency to favour female students was Mike, who, like Ray, believed that he is not gender-biased but contrary to his peer, pictured a male scientist when asked about his image of the scientist. The responses of the remaining five interviewees varied significantly in the expressed level of consciousness regarding their gender bias toward scientists as well as their gender-specific treatment of students. Included among teachers' responses from this group are those of Zoe and Mary. Zoe could be identified as the participant who expressed the highest level of awareness of her own gender bias toward scientists as well as students, and Mary as the one who demonstrated the lowest level of awareness. While Zoe offered her frank opinion about her own stereotypes and possible gender biases without probing, it was often necessary to probe for clarification and ask Mary a question in different ways in order to get a proper response. Mary, who obviously had difficulties to deal with her prejudices, rarely answered directly to a question, deviated frequently from the topic being discussed, and got repeatedly entangled in her arguments because her messages were at times conflicting.

In summary, the level of understanding of teachers' own gender biases and the extent to which they try to raise students' awareness of gender-related issues in S&T varied substantially among participants. As could be seen from the statements above, a couple of teachers were well aware of their own stereotypes and actively counteracted them in their S&T teaching by discussing gender roles in general and, for instance, the contributions of female scientists in particular. Contrarily, some teachers were oblivious of the fact that the way they teach S&T might be influenced by their own biases or that they, by not discussing stereotypes with students, might corroborate students' biased perceptions of the scientist. When comparing each participant's report, a predominantly positive relationship between an individual's gender bias toward the scientist and toward the student can be found. As could be seen from various excerpts of the interview transcripts, the degree of awareness of one's biases and stereotypes differed significantly, which has to be taken into consideration when interpreting the data since a participant that claims to have no personal biases could very well unconsciously reveal biased behaviour in her/his responses.

CHAPTER V

DISCUSSION AND CONCLUSION

A. Discussion of Quantitative and Qualitative Data

Most of the findings from the analyses of the quantitative data were confirmed by the qualitative data. In those cases where no significant relationships among the most important variables were found with quantitative means, the data from the interviews revealed some possible and plausible explanations. However, there were a few findings that could not be explained by either the quantitative or qualitative data. For these findings, literature was used to find possible explanations.

The main aspects that were explored in the context of teachers' attitudes toward S&T teaching were: (1) teachers' knowledge; (2) teachers' experiences; (3) teachers' confidence; (4) teachers' expectations; (5) teachers' beliefs; (6) teachers' bias; and (7) teachers' level of awareness. Overall, the calculated average score suggests that grade 4 to 8 teachers' attitudes toward S&T teaching are positive and that the higher their degree of content knowledge, the more positive are their teaching experiences. This positive attitude also corresponds with childhood learning experiences; that is, the more positive their childhood/school experiences, the more confident they are with their overall teaching. Another key finding regards teachers' awareness of gender issues. Data indicate that those teachers who had low expectations for students, particularly female students were also those who believed more in gender equality; and that those less aware of their beliefs and biases concerning gender issues in the S&T classroom and in S&T in general had higher expectations of students.

The survey data indicate that significant differences exist between teachers who obtained a bachelor's degree in science (BSc) and those who did not. Teachers with a BSc were more confident in their S&T teaching than their counterparts without a BSc. This confidence possibly results from teachers' belief that they are adequately trained to teach S&T, which is rooted in the teachers'secondary science education and background acquired through tertiary education in science. Further, analysis of the quantitative data indicates that teachers with a more positive attitude are also more knowledgeable about new S&T topics. The interview data suggest that some teachers with lower level science education were very confident as well but this confidence was restricted to grade 6 and lower. Accordingly, these teachers reported that they were comfortable teaching at this level because they knew the content well.

Teachers' experiences played an important role, too. The interview data indicated that if a teacher experienced S&T negatively in high school, it is more likely that s/he developed a more negative attitude toward the teaching of S&T that can lead to apprehension. This apprehension can further lead to a teacher's inclination to focus on strands and topics s/he feels comfortable with, which is more often related to physics and mathematics than to any of the other sciences. Moreover, a teacher's attitudes to S&T teaching may be more negative if s/he had negative experiences with students and their parents. Overall, the assumption that more teaching experience leads to more confidence in, and comfort with, the subject taught was neither confirmed nor denied by the findings in this study. Data from this research indicate that the quality of one's teaching is of greater importance than her/his teaching duration, and that both have an impact on teachers' attitudes toward S&T teaching.

One of the main outcomes of the analyses is that teachers with positive attitudes toward S&T teaching also perceive their students' attitudes toward S&T learning as primarily positive, which might enhance a teacher's job satisfaction and self-esteem. The extent and direction of a teacher's attitude toward S&T teaching, however, seems to depend on several other factors as well. If a teacher's self-confidence is high, the relationship between her/his attitude to S&T teaching and students' attitudes to S&T learning is stronger than if her/his self-confidence is low. Further, teachers whose expectations for students are not met, develop a more negative attitude than teachers that are satisfied with their students' performance and participation in the S&T classroom. The analyses further suggest that teachers who care for students, and experience positive individual breakthroughs, tend to attain a more positive attitude than those who do not develop a strong bond with students. Moreover, educators with a teaching philosophy that primarily focuses on helping students may develop a more negative attitude toward S&T teaching if they cannot fulfill their objective because of a perceived indifference or unwillingness of students to learn.

Another outcome of this study is that no association between teachers' attitudes and their perceptions of gender differences in students' attitudes was found by quantitative means but the interview data suggest that a relationship, though rather weak, may exist. That is, teachers' attitudes to S&T teaching seemingly depend more on their experiences, beliefs, and expectations regarding students of different genders than their actual perceptions of gender differences in their students. The qualitative data suggest that a teacher's attitude to S&T teaching may vary with the degree her/his beliefs are confirmed and/or expectations are met by students of a specific gender. Particularly important in this regard is the level of awareness; a teacher who is aware of her/his beliefs and expectations for female or male students and is content with the situation, may attain a more positive attitude to S&T than a teacher who is similarly aware of the situation but is disappointed or frustrated about how things are with students. On the other hand, a teacher who is less aware of gender differences may attain a more positive attitude than a teacher whose level of awareness is high. Further, teachers' beliefs, experiences and expectations may lead to an attitude that is more negative if female students exhibit a negative attitude to S&T learning but their attitudes may be unchanged if boys exhibit a negative attitude. A plausible explanation for inconsistencies in the relationship of teachers' attitudes and gender differences in students' attitudes may be that some teachers believe that gender differences in students are unrelated to the teacher because of biological traits in students or social circumstances that are more influential in students' attitudes.

The analyses further suggest that teachers' attitudes are affected negatively if they fail to motivate girls to learn and excel in S&T. This relationship can vary, depending on the teacher's own gender identity, her/his personal experiences, expectations and beliefs. It was found, for instance, that some teachers' attitudes are more negative if they believe that female students must perform well in S&T in order to succeed in life but perceive girls in their S&T classroom as disinterested.

The analyses of the survey data suggest that no association between teachers' attitudes and their beliefs about scientists and S&T exist while the interview data indicate that both variables are somehow related. Similar to the aforementioned findings regarding attitudinal relationships, the strength of the associations depends on teachers' expectations, their awareness, and their beliefs. The belief that everybody can become a scientist seems to be widespread among participants but there are major differences in the strength of this belief, which can result in attitude differences. For example, a teacher who strongly believes that everybody can become a scientist, had personal experiences that support her/his belief, and is not aware of gender inequalities in the scientific and technological fields, may attain a more positive attitude toward S&T teaching than a teacher who principally believes the same but is aware of the male-dominance of S&T, social inequalities, and gender roles that hinder females to enter these fields.

Lastly, the findings suggest that a teacher who (a) has limited awareness of gender differences and inequalities; (b) is convinced that no cognitive or affective differences exist between females and males; (c) believes that gender does not play a role in science, meaning that science is gender-neutral and scientific and technological knowledge does not reinforce gender and other social hierarchies; (d) believes that most female students perform as well or better than male students; and (e) recognizes the existence of gender inequalities in, for instance, the workforce but believes that they have no impact on S&T per se may attain a positive attitude toward the teaching of S&T.

The discussion will be based on the three key study questions. As well, for each question both quantitative and qualitative data will be incorporated.

1. How do teachers' knowledge and school-related experiences impact their attitudes to and confidence as well as comfort levels in teaching S&T?
2. In which way are teachers' attitudes toward S&T teaching influenced by their perceptions and expectations of students' attitudes to S&T learning, their

perceptions of gender differences in students' attitudes, as well as their beliefs about scientists and S&T?

3. What are the implications of teachers' attitudes and perceptions for their S&T teaching in general, and for their attitudes toward students of different genders in particular?

1. How does teachers' knowledge and school-related experiences impact their attitudes to and confidence as well as comfort levels in teaching S&T?

Quantitatively, aspects regarding teachers' educational background were investigated in the demographic section of the survey: (a) the levels / years the participants took courses in biology, chemistry, physics, and mathematics in high school, and (b) the university degree in science obtained by the participants.

(a) Quantitative data substantiated some but not all aspects of this hypothesis. This is because information gathered regarding teachers' high school background was incomplete or contradictory. Further, the data regarding differences between teachers with a bachelor's degree in science (BSc) and those without a BSc were significant in 2 out of 10 variables only. Based on their expertise and training, teachers with a BSc were more confident in their S&T teaching than those without a BSc. The data concerning the educators' teaching experiences disclosed no significant differences between teachers with experiences above or below eight years of general teaching and those above or below five years of S&T teaching. In contrast, quantitative data about the teachers' continued S&T learning revealed a significant positive relationship with their attitudes toward S&T teaching to support this hypothesis.

The qualitative data confirmed the quantitative data regarding the relationship between teachers' knowledge and experiences in S&T teaching and their confidence/comfort level. That is, interview data revealed that those participants who said they feel very confident and comfortable in teaching S&T had the highest degree of education in S&T (BSc or attainment of some university courses in sciences) and substantial S&T teaching experiences. In addition, interview data suggest that the confidence or comfort level of teachers with low level science background is often restricted; it depends primarily on the educator's knowledge of the teaching material and, to a lesser extent, on the duration of S&T teaching experience. That is, teachers with low level science background and not much teaching experience may be very confident because they know the content well. On the other hand, teachers who have limited knowledge of the teaching material may be less confident even though they have a lot of experience. This finding confirms what Woolnough's (1994) extensive study, cited in Osborne et al, (2003), revealed - teachers were most confident teaching what they felt most comfortable with or were specialized in.

In addition to the relationship between teachers' attitudes to S&T teaching and the high school courses taken, the association between the variables, *gender,* and, *courses taken in high school,* was investigated. The fact that no significant results were found when computing the relationship of the variables (Crosstabs and Chi-square test) is most likely because the number of cases was too low for statistical analyses.

More female than male participants completed grade 13 biology, while comparatively more male than female participants completed grade 13 physics. Further, a higher percentage of female participants completed grade 13 chemistry and a higher percentage of male participants completed grade 13 mathematics. Although there are gender differences between those who completed biology and physics, these percentages are low, thus necessitating a cautionary note in their discussion. That is, these data have to be discussed cautiously due to statistical limitations, however, it can be said that their outcome corresponds with a well known trend in science education research. Research has shown that female high school students have a preference for biology while male students prefer other science subjects such as physics (Osborne et al, 2003; Weinburgh, 1995). In her meta-analysis, Weinburgh (1995) cited study findings from Schibeci (1984) describing that female students show a more positive attitude toward biology and male students a more positive attitude toward physics and chemistry.

The trend of more female students favouring biology and more male students favouring physics is also evidenced by the numbers of females and males enrolling in biology and physics undergraduate university programs (Canadian Association of University Teachers, 2007). That female and male participants in this study had similar preferences when they were high school students as the students in the studies cited above is partially confirmed by the qualitative data. Similar to the studies cited above, as high school students, female participants in this study had a preference for biology while male participants preferred physics. This finding is confirmed by the qualitative data, which indicates that the three male interviewees were comfortable in teaching the all science subjects; however, they had apprehensions about teaching biology. The female participants' preference for biology over physics is also present, and is evidenced, for instance by Liz descriptions of her peers who studied physics and chemistry at high school and physics, computer science and engineering at university. Furthermore, her description of people who work in these areas was ambiguous, partially gender-biased, and deferential, which further confirmed and reflected her uneasiness in these areas. Similarly, Amy's apprehension about what she referred to as "the so-called harder sciences" was confirmed by her assertion that she never liked math, did not take any physics courses in high school, and she was not certain whether female students have the same abilities to learn physics as male students. Liz, however, mentioned that she believed no gender differences in students' cognitive abilities exist. Amy's science anxiety derived most likely from her own experiences in primary and secondary schools where she felt "a little intimidated" by science in grade 9 and thought in grade 13 that her biology class was "absolute horrid". Although no other interviewees described their science high school experiences as explicitly negative it may be safe to conclude that all participants were more or less influenced by their beliefs about mathematics and science resulting from their own school experiences as described by Stuart and Thurlow (2000).

The two examples from this study indicate that a teacher's negative attitude toward mathematics or science that is rooted in her/his high school experiences does not change with expertise in S&T teaching, as in Amy's case. Amy, who was afraid of mathematics and science as a high school student, has not recovered from her negative experiences, and consequently, demonstrated in the survey as well as in the interview, an overall negative attitude to S&T teaching. Liz, on the other hand, has not been able to fully shake off her ambiguous feelings about S&T teaching. However, the fact that she consciously rated her attitude more positive than Amy could be interpreted as a sign of change with time. Liz has been teaching S&T for 20 years while Amy has been a S&T teacher for only three years.

What does this apprehension toward hard sciences and mathematics entail? Does science anxiety even if it is on a small, subconscious level, impact one's S&T teaching? Results from the qualitative data suggest that anxiety about the subject does influence the way teachers teach S& T. The interviews with some female teachers indicate that a teacher with science anxiety is inclined to shift focus to strands and topics they feel more comfortable with; furthermore, they may teach abstract scientific subjects, especially those they feel uneasy about, with hesitation.

(b) Survey data indicate that there exist significant differences between teachers who obtained a bachelor's degree in science (BSc) and those who did not. Accordingly, teachers with a BSc were more confident in their S&T teaching than their counterparts without a BSc. This confidence possibly results from teachers' belief that they are adequately trained to teach S&T and that their level of scientific and technological knowledge is so high that they would consider themselves experts in this area. This confidence is rooted in the teachers'secondary science education and background acquired through tertiary education in science.

The overall outcome of no difference between teachers with BSc and teachers without Bsc as well as the significant positive correlation found between the variable 'belief in adequate training' and the variable 'confidence in expertise' is confirmed through the qualitative data. While all interviewees said that they are confident or very confident in teaching S&T, survey data indicate that it has also been found that those interviewees who rated their confidence and comfort level highest in S& T teaching also had the highest degree of education in S&T (BSc or taking some university courses in the sciences) as well as substantial S&T teaching experiences. The confidence/comfort level of the interviewees without a BSc or other additional science training was in most cases restricted to the subjects and curriculum strands they taught before in the lower grades (grade 6 or below).

It is noteworthy that most grade 4 to 8 S&T teaching in the studied school districts is done by non-specialty teachers (compare definition of ‘specialty science teacher’ on p. 6). That is, all S&T teaching is done by non-specialty teachers at one third of the 42 elementary schools that provided additional information regarding the number of specialty teachers at their school. The other two thirds of those schools have one or more S&T specialty teachers, who constitute between 8% and 55% of the staff of each school. That implies that a substantial percentage of S&T teaching in grades 7 and 8 is done by teachers who lack science-specific background and who, consequently, might not feel as comfortable in teaching this subject as teachers with substantial science background.

Two aspects concerning educators’ teaching experiences were quantitatively examined to study the relationship between teachers’ attitudes toward S&T teaching and their level of experience: the duration of teaching experience the participants gained in general, and the duration of teaching experiences the participants had in the S&T classroom.

The quantitative data failed to reject the hypothesis that the years of teaching experiences have a measurable impact on the attitudes they adopt toward S&T teaching. This is based on the independent samples t-test that showed no significant differences between the group of teachers with science teaching experience of less than five years and those with science teaching experience of more than five years. Also, no significant differences was found between the group of teachers with general teaching experience of less than eight years and the group of teachers with more than eight years of general teaching experience. One explanation for this outcome could be that the chosen cut-off times (medians) were not meaningful for the examination of the assumed relationship between teachers' attitude toward S&T teaching and their teaching experiences since elementary school teachers most likely feel comfortable with their teaching after a shorter period of time than eight years of general or five years of S&T teaching.

This quantitative finding is in part confirmed by qualitative data. The interviews revealed that two out of four teachers with years of S&T teaching experiences that are below the medians (between two and four years) were extremely confident while the other two teachers had the least confidence in their S&T teaching. Similarly in regards to general teaching - two out of three teachers with numbers of years of general teaching experiences below the medians (between three and four years) were extremely confident in their teaching. The qualitative findings revealed that five out of six teachers with extensive teaching experiences (more than five years of S&T and eight years of general teaching) were very confident in their teaching. These outcomes, although somehow similar to those of other studies that have found that the duration of teaching experience is positively correlated to an educator's confidence level (Liu & Ramsey, 2008), show that it is difficult to determine the number of years of teaching needed for a teacher to feel confident and comfortable with teaching a certain subject. Nonetheless, Liu and Ramsey (2008) pointed out that: "As teachers gain more experience in teaching, they become more confident in dealing with students and parents" (p. 1182). Liu and Ramsey's (2008) research as well as this study suggest that confidence gain is a gradual process that not only depends on the time spent in the classroom (quantity) but the kind and extent (quality) of the teaching experiences obtained by a teacher. The ‘quality’ of a teacher’s experience could be seen in, for example, the way the interviewees identified what makes teaching S&T enjoyable for them. Some teachers expressed the great joy they experience when students get really excited about learning new things in the S&T classroom or the deep satisfaction teachers attain when they find a good way to explain difficult scientific concepts to students. A teacher’s confidence/comfort level, and with that her/his attitude to S&T teaching, therefore, increases with her/his enjoyment of teaching, which oftentimes, is related to the students they teach. On the other hand, negative experiences with students and parents or frustrations about insufficient resources as described by a couple of interviewees, led to negative attitudes toward S&T teaching and to dissatisfaction with the job, generally.

The last variable used to quantitatively investigate whether teachers’ attitudes toward S&T teaching are related to their background knowledge is the educators’ interest in, or degree of knowledge of novel issues in S&T. The quantitative data revealed a significant positive correlation between the scale *attitudes to S&T teaching* and the scale *knowledge of S&T issues*. Furthermore, it was calculated that around 44 percent of the variation of attitudes toward S&T teaching among teachers in this sample can be explained by their knowledge of or interest in novel S&T issues. Those survey respondents that ranked their level of knowledge in certain S&T areas such as environmental issues, space exploration, or nanotechnology high, tend to show more positive attitudes toward S&T teaching than those that rated their level of information low. This finding supports what one might expect since teachers that are interested in novel scientific issues discussed in the media are most likely to be enthusiastic about discussing them in their S&T classrooms. The reason for this could be manifold: it might be because the teacher is simply interested in the topic; recent information about the topic is widely available and easily accessible; and, as some interviewees pointed out, it may be because students are more interested in topics they heard about at home and which can be linked to their everyday life.

Overall, the assumption that more teaching experience leads to more confidence in the subject taught and an enhanced overall job satisfaction as indicated by some researchers (Hean & Garrett, 2001; Liu & Ramsey, 2008; Zembylas & Papanastasiou, 2006) was neither confirmed nor denied by the findings of this study. Data from this study indicate that the quality of one's teaching experience is of greater importance than its duration, which has an impact on teachers' attitudes toward S&T teaching.

2. In which way are teachers' attitudes toward S&T teaching influenced by their perceptions and expectations of students' attitudes to S&T learning, their perceptions of gender differences in students' attitudes, as well as their beliefs about scientists and S&T?

The quantitative findings suggest that teachers who perceive their students' attitudes in the S&T classroom as positive and perceive no gender differences in students' attitudes toward S&T learning tend to have no prejudices about scientists or S&T. This outcome is based on the existence of (a) a significant positive correlation between teachers' perceptions of students' attitudes toward S&T learning and their perceptions of gender differences in students' attitudes toward S&T learning; (b) a significant positive correlation between teachers' perceptions of students' attitudes toward S&T learning and their beliefs about scientists and S&T; and (c) a significant positive correlation between teachers' perceptions of gender differences in students' attitudes toward S&T learning and their beliefs about scientists and S&T. The quantitative findings further suggest that teachers' who have positive attitudes toward S&T teaching perceive their students' attitudes to S&T learning as positive as well, while teachers' attitudes toward S&T teaching are seemingly neither related to their perceptions of gender differences in students' attitudes toward S&T learning nor to their beliefs about scientists and S&T. This outcome is based on the existence of (d) a significant positive correlation between teachers' attitudes toward S&T teaching and their perceptions of students' attitudes toward S&T learning; (e) no significant correlation between teachers' attitudes toward S&T teaching and their perceptions of gender differences in students' attitudes to S&T learning; and (f) no significant correlation between teachers' attitudes toward S&T teaching and their beliefs about scientists and S&T.

Additionally, the outcomes of the multiple regression analysis of the dependent variable, *perceptions of gender differences in students' attitudes*, with the combined variable, *beliefs about scientists and S&T/perceptions of students' attitudes toward S&T learning*, put the assumption forward to consideration that these variables are all related to teachers' attitudes to S&T teaching. The reason for this assumption is that significant correlations between the combined variable and two of the three individual variables mentioned above were found.

The analysis of the qualitative data partially confirmed the quantitative findings. That is, the existence of the four aforementioned positive correlations was substantiated by interview data; the non-existence of a significant relationship between teachers' attitudes toward S&T teaching and their perceptions of gender differences in students' attitudes or between their attitudes and their beliefs about scientists and S&T was not confirmed by interview data. The qualitative data, in contrast to the quantitative data, suggest the existence of an important relationship between teachers' attitudes toward S&T teaching and their perceptions of both gender differences in students' attitudes to S&T learning as well as their beliefs about scientists and S&T.

Aspects regarding teachers' attitudes toward S&T teaching and their perceptions of students' attitudes as well as gender differences in students' attitudes to S&T learning will be discussed first (a) and aspects regarding teachers' attitudes toward S&T teaching and their beliefs about scientists and S&T will be discussed second (b).

(a) Teachers' attitudes and their perceptions of students' attitudes

Quantitative data suggest that the more positive teachers' attitudes to S&T teaching are the more positive are their perceptions of students' attitudes to S&T learning. That is, a teacher who is confident, enjoys and feels comfortable with teaching S&T believes that her/his students are interested in the topics s/he covers, have no problems in understanding S&T, think scientifically, enjoy her/his class, and do not think that S&T is boring.

The comparison of individual variables of both the attitudinal scale and the student perception scale suggest that the interviewees generally enjoy teaching S&T and that they are very confident in it. This can be seen from the high scores given for statements that focus on students understanding of what the teacher explains in the S&T class, for example. At the same time, their scores in other variables suggest that they perceive students' learning of S&T as low, which seems to be contradictory. A possible explanation could be that the interviewees do not see a diametrical connection between their teaching of S&T and students' understanding of it, which was somewhat confirmed by the qualitative data. For instance, all interviewees mentioned at some point during the interviews other reasons than the way they teach for students' difficulties with the content. At the same time, the statements of three teachers suggest that they see a connection between teaching and learning, only that they do not refer students' 'tuning out' during class to themselves. These teachers offered as an explanation for students' learning difficulties that students are intimidated by or scared of S&T because of previous experiences with other S&T teachers who had overly high expectations or other personal problems. The fact that two of those three teachers had a very positive attitude toward S&T teaching in general further suggests that teachers' attitudes may be negatively related to their perceptions of students' understanding of S&T concepts.

Qualitatively it was found that interviewees identified students' behaviour directly or indirectly as the primary factor associated with their feelings toward S&T teaching. While a few teachers expressed frustration about students' apprehension or unwillingness to learn S&T, most of them articulated their enjoyment based on the positive attitudes of students and the constructive and inspiring interactions teachers had with students in the S&T classroom. The positive relationship of both variables can be demonstrated with the statement of one of the interviewees that exemplifies the opinion of most participants: "If they love it, then I love it." Moreover, this statement illustrates that a teacher's satisfaction with her/his S&T teaching relies heavily on the feedback they get from their students since it implies at the same time that the teacher is dissatisfied with her/his teaching when students dismiss what s/he tries to convey to them.

The findings are consistent with a phenomenon that Stenlund (1995) described as the need for teachers to obtain positive feedback from their students in order to heighten their own sense of professional enthusiasm. In other words, teachers that experience their students in the S&T class as motivated and interested in learning what they teach are more passionate about their S&T teaching as well. This has been expressed by several teachers during the interviews. Zoe, for example said: "I would definitely choose to teach science as one of my top subjects because I feel that students can get really excited about learning it." On the other hand, educators that encounter negative attitudes toward S&T learning in their students feel discouraged on the job by their students' lack of motivation (Stenlund, 1995). Ray, for instance, who revealed frustration on the job during the interview, openly said that the majority of students have a negative attitude toward S&T. He exemplified this by explaining in a cynical tone that "kids have a negative story in their head about [for instance] math" and that they "limit themselves" by tuning out during the lesson, not doing the homework, not asking questions in class, not seeking extra help, not studying and preparing for tests and quizzes, and, consequently, failing.

Hargraeves (2000) found in a more recent study that teachers gain psychic and emotional rewards from exceptional breakthroughs with individual students and from positive feedback from individual students as well as whole class groups. This phenomenon has been described by several study participants as well – even by those who were not overly satisfied in their job such as Ray: "I mean science competitions this year – I don't know who had more fun, me or the kids, you know? I like it - its fun."

Hargraeves (2000) interpreted his findings as an indication of strong emotional understanding between teachers and students that is particularly distinct in elementary classrooms. Such a strong emotional bond was not explicitly mentioned by the interviewees since the quality of the teacher-student relationship was not discussed. Nevertheless, qualitative data suggest strongly that most of the elementary teachers who participated in the study cared profoundly for their students. Moreover, from the way several interviewees described their 'teaching philosophy', their approach to S&T teaching, it became apparent that the majority of teachers understand their job as primarily to be of assistance to students, to spark their curiosity, to make learning S&T fun for them, and to help them comprehend not just the content but to learn about the importance of S&T for their lives and the world around them. To help students grasping the overall importance of S&T, it is nonetheless crucial to focus on the teaching of scientific concepts as highlighted by few interviewees. However, main finding lends support to Skilbeck's (2007) suggestion that most teachers understand their job as primarily to be of service to students and that they find greatest satisfaction in contributing to the growth and development of children. Therefore, it can be assumed that a teacher who cannot fulfill her/his objective of helping students to grow in the cognitive as well as affective domain because of a perceived indifference or unwillingness of students to learn, might be dissatisfied with her/his teaching and develop a rather negative attitude to it. This can be seen at the survey responses of teachers such as Ray or Katy, who rated their perceptions of students' attitude toward S&T learning relatively negative (lowest and second lowest score of all interviewees) and whose attitude toward S&T teaching was in the lower half of the attitude scale. However, a few interviewees rated their attitude to S&T teaching lower than Ray and Katy but seemed to be less dissatisfied with their students' performances since they rated their attitude to S&T learning slightly higher than Ray and Katy. It is noteworthy that most interviewees, although they rated their own as well as their students' attitude to S&T relatively negative, did not – or at least not openly – express their dissatisfaction with the job or the students during the interview. Katy, for instance, who gave the impression that she enjoys teaching S&T by stating that she has always enjoyed science and that she has always known that she will be a teacher, also sowed the notion that her students enjoy learning S&T while mentioning that a lot of them do not show any interest in S&T or 'zoom out' during class. Katy seemed to have made similar frustrating experiences in the S&T classroom as Ray and, therefore, rated students' attitude to learning and her own attitude to teaching S&T as low as Ray. The fact that Katy, in contrast to her colleague, talked about positive experiences with students to a wider extent and in a different way than Ray, shows that a difference in their perspectives prevails. While Ray seemed to be disillusioned since he believed that he lost the battle against students' (and parents) ignorance, Katy apparently remained somewhat optimistic; she feels confident that she does a good job as S&T teacher since she has been able to spark interest in even those students that were apprehensive about S&T initially.

The aforementioned interpretations of the association between teachers' attitudes and their perceptions of students' attitudes are based on the assumption that teachers' perceptions reflect teachers' observations in the S&T classroom. This assumption could be incorrect if teachers' perceptions do not mirror what actually happened in the classroom, which is likely – at least to a certain degree – since observations are normally subjective, meaning what one sees is influenced by the interpretation of what one knows (Tobin, Briscoe, & Holman, 1990). One reason for this belief that results in misconception could be denial caused by, for example, the unconscious attempt to prevent discouragement on the job or disappointment of students. An example for the possible discrepancy between a teacher's perception of the classroom environment and the interactions that in fact happen in the classroom is described by She and Fisher (2002). In their study, the researchers observed two teachers in their science classrooms and compared their observations of the teachers' behaviour with the teachers' self-perceptions as well as the students' perceptions of the teachers' behaviour that had been surveyed beforehand. She and Fisher (2002) revealed that the perceptions of certain behavioural patterns of one of the studied teachers were very similar to teachers' self-perceptions as well as students' perceptions of the teacher's behaviour but were deviant in the case of the other teacher. It turned out that the latter teacher had interactions with primarily ten students, which is considerably less than half of the class, without noticing that she communicated with the rest of the class substantially less.

Following Hargraeves' (2000) and Stenlund's (1995) suggestion that teachers seek emotional reward and positive feedback from their students to avoid discouragement on the job, it can be assumed that most participants have strategies in place that allow to enter the S&T classroom anew everyday with a positive attitude. As this research revealed, the strategy chosen by most of the interviewees was to make or keep their students interested and happy by reducing the amount of sedentary, academic work, such as reading and writing, and increasing the amount of active, exploratory work such as hands-on activities, which will be discussed in more detail below in regards to teacher's perceptions of gender differences in students' attitude.

The analysis suggest that teachers do not relate negative perceptions of students' attitudes to their own behaviours or attitudes; students who are apparently not interested in a topic or class unit, who are bored or dismissive attain such an attitude because of other, mainly individual reasons. Those individual reasons or personal constrains are due to anxiety caused by previous negative experiences with the subject, social problems in the family or with peers, hormonal shifts, and high expectations caused by overstimulation by other sources. Therefore, some participants thought that student's negative attitude toward S&T learning cannot - or only to a very limited degree - be changed by the educator. However, most interviewees mentioned 'success cases', meaning they spoke of an attitude shift in students from negative to positive, which they inadvertently attributed to their teaching, but none of them mentioned at any time during the interview a shift from positive to negative. This may be due to the teachers' abovementioned longing for positive feedback that is necessary to avoid discouragement and keep them motivated on the job. Another reason could be that the participants, albeit confidentiality was assured, were rather concerned about being evaluated and judged on their job, probably because they are used to frequent teaching evaluations.

The quantitative outcome of no bivariate relationship between teachers' attitudes to S&T teaching and their perceptions of gender differences in students' attitudes to S&T learning were confirmed by qualitative findings. Participants' perceptions of gender differences in students' attitudes were seemingly unrelated to their own attitude. That is, interviewees with an overall positive attitude who very much enjoy and feel comfortable teaching S&T and interviewees who would rather teach another subject perceived gender differences in students' attitudes in a very similar way. In contrast, interviewees' perceptions of gender differences in students' attitudes may vary substantially in teachers who otherwise demonstrate a very similar attitude to S&T teaching. For instance, Joan's perception contrasted with Liz's, who perceived distinct gender differences particularly in students' interest in S&T, while their attitudes were the same or very similar based on the quantitative and qualitative data respectively. An explanation for this occurrence may be that participants' perceptions of girls and boys in the S&T classroom were based on students' gender-related attitudes and behaviours that were mostly unrelated to teachers' attitudes. That is, most teachers had very similar experiences with the majority of female and male students due to similarities in girls' and boys' attitudes and behaviours. Those attitudes and behaviours are normally rooted in the way the students grew up (nurture) and in their physiology (nature), which is often analogous among children of the same sex in a given cultural and social environment. Consequently, teachers' experiences with female and male students of different social/cultural backgrounds or different biological traits may be dissimilar. Since a discussion of differences in students based on 'nurture' would exceed the scope of this research, only the 'nature' aspect will be analyzed, ignoring the fact that both 'nurture' and 'nature' overlap.

One reason why teachers' perceived different – or similar – attitudes toward S&T learning in girls and boys might have been that the children they taught differed in their developmental stage, which is primarily age- and consequently grade-related. For instance, while Liz has taught young children and adolescents up to grade 8, Joan has only worked in the S&T classroom with student up to grade 6. That is, Liz, more than her colleague Joan, most likely attended to students in puberty. This is a critical developmental phase since it is then when young people normally undergo biological processes that result in physical and psychological changes that substantially differ between females and males. Moreover, these young students perceive expected gender roles more pronounced and pressing when entering puberty than before this change, which not only affects girls and boys differently but might result in attitudinal gender differences regarding school. Catsambis (1995), for instance, described a gender gap in students' attitude toward S&T learning with more girls than boys disliking S&T that appears in middle school. Similarly, Kotte (1992) who reported that the sharpest increase in gender differences in students' attitudes toward science takes place between the ages of 10 and 14 years. Given these findings, it can be assumed that participants of this study perceived similar gender differences in their students since they were in the age range of approximately 9 and 14 years. Since the primary purpose of the study was to investigate teachers' attitudes toward the teaching of S&T and only secondary their perceptions of students, it is not possible to make an informed proposition about when gender differences in students' attitudes occur based on this findings. It is, however, possible to hypothesize about the occurrence of gender differences based on the analyses of the quantitative and qualitative data.

Quantitative findings suggest that most participants generally perceived female and male students' attitudes toward S&T as somewhat equal and thought that girls' and boys' motivation to learn S&T was even more alike (highest average score). However, given that all mean scores of the gender scale are between 'neither agree nor disagree' and 'somewhat agree', and that range and variation of participants' ratings were rather wide, it becomes evident that some participants most likely have perceived gender differences in students' attitudes toward S&T learning. Noteworthy is that participants overall believed that girls' and boys' attitudes are more alike in the affective domain than in the cognitive domain, meaning if they observed any gender differences then in the degree students comprehend S&T. This stands in contrast to the mean ratings of the interviewees who on average thought that the level of similarity between girls' and boys' attitudes is very much the same in the affective as well as the cognitive domain. This was particularly demonstrated by Mary and Tom who gave all variables the same score, with the difference that Tom neither disagreed nor agreed and Mary somewhat agreed with the assumption that both genders attain the same attitudes in the presented aspects. The fact that they did not differentiate at all between the variables in this scale may be an indication for their unambiguous opinion based on experience. It could also mean, however, that they were unaware of or imperceptive to gender differences in students' attitudes.

Quantitative data further showed that other interviewees did perceive gender differences in one of the domains but not the other. Katy, for instance, stated that girls and boys attain more or less the same attitudes toward S&T in regard to their enthusiasm but not in their cognitive abilities. Contrarily to Katy's were Ray's responses since he stated perceiving distinct gender differences based on students' attitudes in the affective domain but not in the cognitive sphere. An explanation could be that girls' and boys' engagement in Katy's S&T classes was mainly identical while it was predominantly dissimilar in Ray's classes, and vice versa regarding students' degree of understanding of scientific concepts. It is important, however, to remember that, with the exception of one, all mean score ratings of this scale lay between the statements ‘neither disagree nor agree’ and ‘somewhat agree’, which means there is a slight tendency in the studied population to think that there are no gender differences neither in the variables that belong to the affective domain (e.g., motivation to learn S&T) or those belonging to the cognitive domain (e.g., understanding of scientific concepts).

Nonetheless, the analysis of the qualitative data regarding teachers’ perceptions of gender differences in students’ attitudes did not substantiate the quantitative findings. In contrast, the interview data suggest that the participants perceived gender differences in students’ attitudes to S&T. Although all interviewees highlighted the fact that exceptions occur and that it is very difficult to decipher between groups of girls and boys since differences between classes, grades, and individuals are more salient than between genders, they all described in one way or another differences between female and male students they seemingly observed in their S&T classes. In eight out of ten cases, the interviewees cited different approaches of girls and boys to S&T learning and learning in general that reflect commonly held stereotypes of females and males. That is, most girls prefer sedentary tasks in comparison to boys who prefer hands-on activities, are more diligent, more passive, more attentive, more cautious, more reflective, and less kinaesthetic than boys. The question that derives from this outcome is ‘does it impact teachers’ attitudes toward S&T teaching if they perceive girls’ attitudes toward S&T learning differently from boys’ attitudes?’ Further, does it make a difference whether these gender differences are in the affective or cognitive domain? A closer look at the qualitative data from the teachers mentioned above might help finding an answer to these questions. In their interviews, Katy and Ray described both female and male students’ behaviour in the classroom as well as their performance as different but gender differences in students' motivation, or the affective domain in general, seemed to affect their own attitudes more. An explanation for this phenomenon could be that they are more concerned about some girls' lower interest in learning S&T since they know how important this subject is for a child's professional future, which is still bleaker for females than for males in the scientific and technological field. Moreover, the teachers might be disappointed that they are not able to motivate more or all girls to learn S&T. This disappointment along with their own attitude is obviously, as discussed previously, slightly different between Katy and Ray, which probably has to do with divergent experiences and expectations. Katy seemed to be less frustrated about girls who do not participate in the S&T classroom than Ray since she believes that girls, like herself, may nonetheless excel in that area or related fields such as S&T teaching. Katy's expectations for girls, though still high, also seem to be lower than her colleague's in regards to girls' engagement in class since she does not associate it with disinterest or lack of understanding. This, again, is apparently rooted in her own experiences as student since she, like most girls, used to be rather quiet in class and would only participate or pose a question if nobody else did it. Ray does not share this optimism since his personal experiences with female relatives and friends led him to the conclusion that girls do not live up to their potential and miss out on prosperous careers. Ray, in contrast to Katy, seems to believe that female and male students have similar approaches to learning in general, which means a girl that does not engage in the S&T classroom is not interested in the subject and, consequently has difficulties to understand it. This, to him, is only a matter of will, not capability, which could be corrected if students' social surroundings allow it, meaning if parents and peers are supportive. As a consequence, both teachers are somewhat frustrated with their teaching due to the attitudes some female students attain but Katy's attitude to S&T teaching is less negative than Ray's because she believes that she reaches more or less all girls – those that do not participate orally in class included.

Although most interviewees stated that girls and boys are similarly strong in their academic performance, the descriptions that were made regarding gender differences in students' abilities suggest that their attitudes toward female and male students differ due to divergent experiences with and expectations for boys' achievements. The examples that were given by some of the interviewees suggest that more often, teachers expect more female than male students to have stronger language skills and to be the better performing students in assignments that include reading and writing. On the other hand, more often, teachers expect male students to perform orally and manually better than female students. Overall, analysis suggest that in cases where teachers perceived gender differences, it was more often that they described the females as the academically stronger, diligent, high achieving students and that they believed more males belonged to the group of low achieving students. This outcome confirms Jones (2005) assumption that many school teachers still, after 30 years of debate in the UK, perceive males as the lower or under achieving students. The author further explains that these perceptions are largely based on teachers' beliefs and preconceptions about the underachieving boy along with the high achieving girl and only partially based on observations. Moreover, her study revealed that teachers have a rather clear concept of the underachieving male student but not of the underachieving female student and that this relates to underachievement to disruptive, immature, and unfocused behaviour – attributes that are more often related to male students than to female students (Jones, 2005).

However, although the majority of interviewees perceived boys as not performing as well in reading and writing tasks as girls and, as some teachers expressed, not as well as most girls academically in general, that did not seem to overly concern the teachers that participated in this study. One explanation could be that most of the grade 4 to 8 teachers in this study believe that boys will succeed in those areas nonetheless. Another equally plausible explanation for teachers' lack of concern could be that they do not consider reading and writing tasks as crucial for S&T learning as active participation in class because they may believe that an inquiry based, exploratory approach is more important in S&T. This approach, which is often affiliated with a higher degree of interest and a greater willingness to take risks, is according to the majority of interviewees preferred by boys. This perception coincides with the descriptions of male students given by some participants, which is seemingly based on observations as well as their beliefs and probable stereotypes. This finding lends support to Walkerdine's (1989) characterization of teachers' perception of male students. According to her, boys are perceived as challenging, risk taking and disruptive, which is seen to imply an inquiring, questioning mind (Walkerdine, 1989). However, teachers' perceptions or expectations of boys' 'bad' behaviour do not necessarily imply that they attain a negative attitude toward boys. This finding suggests that some teachers tolerate boys' 'bad' behaviour with the explanation that it is hard or impossible to change boys' behaviour. According to Jones (2005), "the 'Boys will be Boys' discourse refers to a tolerance concerning the nature of boys, which is viewed as inevitably involving aggression, fighting, competition and delayed maturity" (p. 271).

The supposition that teachers' expectations for students as well as their beliefs that are based on personal experiences may play a role in their attitudes toward S&T teaching can further be explained using Mike's example. This teacher had high performance expectations for his students in general and girls in particular that were only met by very few students, which apparently frustrated him. This frustration may be due to his experiences in his own class but were seemingly also guided by his conviction that females ought to get a good education. This opinion can be ascribed to his beliefs that are partially based on personal experiences, similarly to those that have been described in Ray's case. For instance, when discussing the consequences of female students' lack of self-esteem, Mike drew a parallel to his two daughters by saying that he and his wife, who is also a teacher, has very high academic expectations for them, which is apparently guided by his supposition of what knowledge is best for his children.

The outcome that teachers hold different expectations for girls and boys has also been suggested by others (Becker, 1981; Jones, 2005). Becker (1981) who studied the underlying reasons for gender differences in teacher-student interactions further proposes that teachers treat their students differently based on these divergent expectations. The same assumption may be made for this study since the interviews revealed that some participants not only have different expectations for female and male students but treat them differently in the S&T classroom. This phenomenon is most likely based on gender bias that came to the fore in some of the interviews.

This study did not include direct observations that would have provided us with data that could explain the interactions between teachers and students in the S&T classroom. However, research based on observations indicates the occurrence of two-way interactions between teacher and student, that is, teacher behaviour is directly related to student behaviour and vice versa (Jones & Wheatley, 1990). Based on sex differences found for variables such as student-initiated interactions, praise, and warnings, Jones and Wheatley's (1990) study further proposes that students drive the behaviour of the teacher rather than the other way around. It has also been suggested that students respond differentially in class in accordance with the sex-role expectations of their teachers and society (Becker, 1981; Jones & Wheatley, 1990). Moreover, a significant positive relationship between teachers' behaviour and female students' attitudes (Cavallo & Laubach, 2001; Jones & Wheatley, 1990; Ware & Lee, 1988) as well as teachers' attitudes and students' attitudes toward S&T learning in general has been found (Osborne et al, 2003).

Based on the aforementioned research as well as the quantitative and qualitative findings, it can be assumed that teachers, whose gender-specific expectations for students as well as their expectations for students in general are not met, attain a more negative attitude toward S&T teaching than teachers whose expectations are met. Furthermore, the analyses indicate that teachers' negative attitudes may have an impact on students' attitudes to S&T learning in general as well as female students' attitudes in particular and vice versa.

As a last point in the analysis of the correlation between teachers' attitudes and their perceptions of gender differences in students' attitudes, one other major factor that could influence teachers' perceptions will be discuss: lack of awareness. That is, the findings suggest that some participants responded inconsistently to questions and statements that involved gender issues because they were not aware of their gender biases or felt uneasy because of ambiguity. For instance, a substantial number of interviewees, even when talking about different learning approaches of students that they associated with a certain sex, did initially not mention differences in female and male students' attitudes. However, the fact that most participants willingly talked about possible gender biases and the possibility of unequal treatment of female and male students after probing suggests that they became aware of their suppositions and stereotypes and started to scrutinize their attitudes toward S&T teaching to a wider extent than at the beginning of the study.

(b) Teachers' attitudes and their beliefs about scientists and S&T

Based on the assumption that some of the previously discussed variables that probably influence teachers' attitudes and their perceptions of students' attitudes may also impact teachers' beliefs about scientists and science as well as the degree of their awareness of biases will be discussed. In the following analysis, focus will be laid on the gender aspect of the proposed association between teachers' perceptions of scientists and of students since teachers' perceptions of gender differences in students' attitudes to S&T learning are linked to their perceptions of students in general, as elucidated in the previous section. The question how these two variables impact teachers' attitudes toward S&T teaching will be discussed in the last part of this discussion section.

Given that quantitative analyses highlight associations rather than directionality between the variables, no conclusions about the causes for teachers' perceptions of scientists are being drawn. Therefore, focus will be laid on the qualitative findings about these perceptions in order so seek an explanation for the detected outcomes.

The analysis of the quantitative data gathered from the scale that measured teachers' beliefs about scientists and their views about S&T revealed similar results in the overall sample as well as the interviewee subsample. The fact that the interviewees agreed slightly more on average with the statements in this scale than the participants overall, and considerably more with the two statements referring to gender issues in S&T, suggests that their opinion about scientists in general and female scientists in particular is more well-rounded than those of the sample population in general. The mean score value for this scale indicates that the studied teacher population attained an overall positive attitude toward scientists and S&T. This attitude is seemingly based on their knowledge about the nature of the intellectual and social activities of the scientist, the nature and aims of science, and the interactions of S&T and society. While a majority of both the study population and the interviewees appear to believe strongly that S&T serves the environment and the world population well (both scores 4.9 out of 5), a difference in the mean scores for one of the two gender-related statements occurred. The interviewees fully and unanimously agreed with the statement "Men and women are equally suitable to become scientists and engineers" in comparison to the overall study population that rated this statement a little lower (5 and 4.6, respectively). This outcome proposes that all interviewees and a substantial number of all study participants strongly believe that no biological sex differences exist that disadvantage female students over male students in regards to S&T learning.

Interview data confirmed this proposition to a certain extent. All interviewees articulated the view that female students are as able to become scientists as male students. Some of them further substantiated their view by explaining that they do not believe in innate sex-related traits such as the ‘male math gene’ that supposedly gives men a biological advantage over women in S&T. However, while there seemed to be no disagreement on the ‘nature’ aspect of gender similarities, the findings from the interviews suggest that some participants were uncertain about existing ‘nurture’ differences between genders that might put women in an unfavourable position over men in scientific and technological fields. An explanation for this phenomenon could be that some teachers were not familiar with the ‘nature-nurture’ debate and social Constructionism, which is probably due to a rather uncritical approach to gender related societal issues. This uncritical gender state seem to have been common with those interviewees who were 30 years of age and younger and had undergone teachers’ training in recent years (roughly from 2005-2009).

The need to help young elementary teachers to bring their beliefs to a conscious level has been described by Stuart and Thurlow (2000) who found that pre-service teachers often bring with them long-held beliefs and prejudices that may drive their classroom practices. Although Stuart and Thurlow’s (2000) study focused on pre-service teachers’ beliefs about teaching and learning science and mathematics, their findings can be expanded to teachers’ beliefs concerning the attributes and personal motivations of a scientist since the image teachers have of a scientist almost certainly guide their approach to S&T teaching as well. Data from this study suggest, for example, that most teachers chose a hands-on teaching approach because they believe that most scientists do a lot of experimental work with their hands, and, as one participant put it, they ought to "get down and dirty and right into it". According to study participants, those scientists that run their own research group and, therefore, spend most of their time reading and writing grant applications and scholarly publication are apparently no 'true' scientists.

Research suggests that the majority of science educators of all grades have inadequate and erroneous conceptions of scientists' work (Carter, Stubbs, & Berenson, 1996; McDuffie, 2001; Rampal, 1992) and that their perceptions of scientists are often synonymous with the stereotypical image of a white male in a lab coat (Chambers, 1983; Mead & Métraux, 1957; Thomas & Hairston, 2003). The abovementioned suggestions from the literature were to some extent confirmed by this research. Although 9 out of 10 interviewees believed that their image of the scientist is gender-neutral and that the gender of a scientist is irrelevant to their work, most of them drew picture of a scientist that was clearly male. Only after probing did they realize that their image of a 'true' scientist is closer to the common stereotype of the male scientist than they had previously thought. This representation could be explained by the fact that most of the interviewees, regardless of their age and years of experience, were convinced that they had overcome their gender-biased preconceptions which, as they stated, are fairly common to society and students. It is, however, an interesting phenomenon that a couple of interviewees who were well aware of the rampant stereotype of the scientist as male did not link this knowledge to their own beliefs and insisted that gender does not matter in the scientific world. A possible reason for this disconnection could be that the idea of the nature of science and scientists as well as the philosophy of science they adopted is so deeply engrained that it is very difficult for them to replace it. A similar conclusion has been drawn by Kahle, Anderson, and Damajanovic (1991) who found in the US and Australia that the gender-role stereotypes held by grade 4 and 5 teachers were prevalent and resilient. More importantly, the researchers suggest that a similarity exist between teachers' beliefs about science and their gender-specific perceptions of children's understanding, confidence, interest, and performance in science (Kahle et al, 1991). The perseverance and resiliency of beliefs about science may be due to the fact that S&T are most significant in industrialized societies. Furthermore, the values and ideas of science that have been carried forward from generation to generation cannot be changed easily because they are one of if not the most important pillars of society. The dominant philosophy of science that replaced religion and superstition in most part by reason and knowledge is supposedly objective and gender neutral. However, the current philosophy of science is controversially discussed among philosophers; several philosophers along with feminist epistemologists think that gender does and ought to influence conceptions and practices of knowledge inquiry and justification. Therefore, science cannot be seen as detached from gender since scientific thought is embedded in society and its philosophical tenets that define who produce knowledge and how. "There is no such thing as philosophy-free science; there is only science whose philosophical baggage is taken on board without examination" (Dennett, 1995, p. 112).

A teacher's belief about the philosophy of science, scientists and their work, as well as gender roles may shape and feed into her/his attitudes toward S&T teaching since an individual's attitude toward any object is, as suggested by, among others, Ajzen and Fishbein (1980), a function of the individual's beliefs about the object and the implicit evaluative responses related to those beliefs. The belief that science and scientific knowledge is gender-neutral seems to be linked to the tenet that the teaching of S&T is gender-neutral as well. This belief has been found in a couple of interviewees and can be exemplified with the statement of one participant who thought that it is of no importance where he obtains the information he uses in his S&T teaching or who provides it. Moreover, this teacher seemingly did not think that it matters whether a scientist, who might serve as a role model for students, is male or female.

Interview data further suggest that teachers who trust that scientific knowledge is gender-neutral also seem to believe that the learning of S&T is unrelated to gender. That is, those teachers who firmly believe that gender is irrelevant for the teaching and conducting of S&T do not think that gender plays a major role in S & T learning; they stated that students of both genders are equally capable to perform tasks that are crucial in learning S&T. Gender similarities in the learning approach to S&T, however, are seemingly not restricted to mental or physical aptitude; teachers' statements also suggest that a similar willingness to S&T learning exist. This willingness or motivation to learn S&T, however, may be exhibited in different ways in female and male students, as suggested by some interviewees, but students' attitudes to S&T learning can, so they say, not automatically be measured in their behaviours in class. Girls might behave differently in class but may learn as much and vice versa. This finding lends support to Walkerdine's (1989) proposition that teachers' beliefs about students' learning potential are informed by their beliefs about gender. Walkerdine (1989) further suggests that boys are positioned as the 'proper learner' because of their seemingly active and sometimes disruptive behaviour in class is interpreted as evidence of an active, inquiring mind. Contrastingly, girls' conforming diligence has been perceived by the teachers as implying rule-bound learning, rather than principled learning (Walkerdine, 1989). These behavioural gender-related attributes apparently have not changed since similar descriptions of female and male students' behaviour have been given by participants in this study.

However, it is important to remember that all interviewees reported that gender differences in students' attitudes to S&T learning exists; however, some of the interviewees believed that these differences are individual, that is, they are caused by personal circumstances and traits of each individual rather than biological sex differences. Consequently, these teachers seem to be convinced that every student who brings the same interest and aptitude into the S&T class will independent of her/his sex succeed in S&T. Additionally, qualitative data suggest that interviewees who believe that female students are as capable and interested in learning S&T as male students attain a relative positive attitude toward S&T teaching. An explanation for this phenomenon could be that teachers enjoy the teaching of S&T more if they are convinced that gender is not an issue in S&T. Teachers with a relative positive attitude also seem to believe that girls and boys have equal abilities and, consequently, similar interests in learning S&T, and that women and men are equally capable and suitable to become a scientist or engineer. On the other hand, teachers who are aware of gender inequalities in the scientific world as well as gender differences in students' attitudes toward S&T that might put girls in a disadvantaged position are seemingly less satisfied with their job and attain a relative negative attitude to the teaching of S&T. Important to remember is that these interpretations are mainly based on the interview data since the information gathered from the questionnaire responses was not as comprehensive and because a significant association between teachers' attitudes to S&T teaching and their beliefs about scientists and S&T could not be found by means of quantitative analysis.

3. What are the implications of teachers' attitudes and perceptions for their S&T teaching in general and for their attitudes toward students of different genders in particular?

One of the most important findings of this study is that the disposition to reflect on gender issues related to S&T and, consequently, the level of awareness of these issues varies considerably between grade 4 to 8 teachers. Further, it is assumed that teachers who do not reflect on their attitudes toward gender roles as well as students' gender-related expectations, and who are not aware of how these factors influence their S&T teaching may choose a teaching approach that conforms to their gender-biased beliefs. This suggested phenomenon is based on the assumption that a person's attitude and belief toward a certain object triggers certain behaviour and that the object itself is not relevant for this mechanism. This general phenomenon has also been described by Renzaglia, Hutchins, and Lee (1997) who studied special education teachers and found that teachers' beliefs and attitudes drive crucial decisions and classroom practices. Moreover, Eccles (1987) proposes in her psycho-social theory of gender-related differences that teachers are powerful socializers who may transmit their gender biases and concerns to students. The extent of this transmission, though, depends as it seems heavily on the educator's degree of reflection and awareness.

As discussed earlier, teacher-student interactions are not one-directional; they are characterized by the process of action and re-action that happens constantly between teacher and student. These two-directional interactions are fuelled by teachers' and students' perceptions and beliefs (Jones & Wheatley, 1990). Although any comments on how students perceive these interactions cannot be made since this study did not include the examination of students, the analysis of the interview data propose that these two-directional interactions took place in the S&T classrooms of study participants as well.

Findings from this study suggest that most grade 4 to 8 educators, even those who believe that it is most important for students to learn and understand scientific concepts, prefer to interact with students by conducting experimental projects that include some sort of practical work. An explanation for this preference could be that most teachers attain contentment and satisfaction in the job when most of their students have fun in S&T class, and when they enjoy the tasks the teacher asks them to carry out. At the same time, teachers might avoid tasks that are unpopular, that cause students to complain, to be bored and dismissive or even disruptive. Tasks that are seemingly unpopular are those that involve reading and writing, particularly with boys who, as mentioned by several interviewees, tend to find assignments that include a theoretical component boring and difficult.

The elimination of negative behaviour, which apparently can be found in boys more often than in girls, is often necessary since boys tend to dominate, for instance, whole class discussion due to their behaviour (Ross, 2000). This occurrence may further lead to teachers' inclination to do more hands-on tasks and, consequently, accommodate more boys than girls since relatively more boys than girls seem to prefer hands-on tasks. However, no support for this assumption was evident in this study since the focus was laid on teachers and not students.

Data analysis suggests further that teachers who believe in science as gender-neutral and, consequently, believe that no gender differences in students' capabilities and approaches to learn S&T exist, might be less aware of differences in students' needs and strengths. This interpretation of the study results is based on the fact that the same interviewees that believed in gender-neutrality of science were also convinced that they always treat female and male students in their S&T class equally. This is apparently not the case and, as delineated earlier using the examples of Katy and Mary, whose interview data suggest that some teachers are not aware that their teaching is partially guided by their own gender bias, that their attitudes toward female students are different from their attitudes toward male students. These teachers seemingly accommodate boys' alleged constant need for action, preference for kinaesthetic tasks, and problems with more academic tasks that include reading and writing more than they support girls who might struggle with hands-on tasks or who do not participate as much as boys in class. Moreover, data suggest that these teachers are less sympathetic toward female students' perceived weaknesses and, consequently, may exhibit an attitude toward female students that is more negative than their attitude toward male students. An explanation for this difference in teachers' attitudes is that they are not aware of the possibility that girls' behaviour is a consequence of their perceptions of gender-specific expectations of teachers, peers, and parents along with their perceptions of teachers' and peers' attitudes. For instance, boys' inclination to dominate in class discussions, to call out more in class and to behave more assertive and disruptive than girls may lead to a more diffident behaviour in female students. This phenomenon has been described by Stanworth (1983) who further suggests that female students may perceive teachers' attitude toward male students not only as accepting but as favouring due to the fact that boys seemed to be more valued and capable. Another similarly plausible explanation for teachers' obliviousness to girls' assumed weaknesses or deficiencies in learning S&T might be that they identify with female students. This identification might lead to more negative attitudes toward girls and probably a more negative attitude toward S&T learning overall since female teachers might be less willing than male teachers to accept when female students do not see the importance of performing well in S&T in order to become a successful and independent woman.

The aforementioned data analyses stress the importance of teachers' awareness and reflection on students', society's as well as their own gender-bias. Constant reflection is necessary since neither society nor the classroom is a static environment. Teaching and learning cannot happen in a predisposed, fixed fashion since it does not occur in a vacuum, meaning a teacher must, at least to a certain degree, constantly adjust to what students convey to class. What students bring with them is, according to some interviewees who have substantial teaching experience, different from what they brought with them 10 or 20 years ago and constant development and change is the day-to-day routine of teachers. Further, due to female and male students' expectations for the teacher and the teaching outcomes that are fuelled by parents and societal expectations, teachers are expected to adjust to these demands continuously. For instance, females are expected to enter the S&T field in much greater numbers nowadays than they used to, which may increase the pressure on girls to do well in S&T and mathematics. However, constant reflection regarding one's teaching might not be sufficient if misconceptions are prevalent and if the beliefs and worldviews of a teacher are 'streamline', meaning if they are not meeting society's and with that a teacher's own expectations for females and males. The constant effort to meet these expectations could cause stress, disappointment, and frustration, which leads to a negative attitude toward S&T teaching.

B. LIMITATIONS

Sample size

There is the possibility that many more grade 4 to 8 school teachers would have participated in this study but were too preoccupied with other school-related duties or not aware of it since they might not have received the letter of information with the call for participation, which was sent either by mail or by e-mail to all school principals in both participating school districts. Other reasons for the extremely low response rate (70 out of approximately 940 grade 4 to 8 teachers = 7.5%) could have been that the principals contacted did not inform the researcher about whether they support the study or not, which delayed the recruiting process and shortened it because of the approaching end of the school year. In the first and second phases of recruiting, teachers could not be contacted directly by the researcher, which could have increased the response rate; experience showed that the response rate was much higher following meetings with teachers during school visits than without personal contact. However, only ten principals granted permission to visit their schools. Another possible explanation for the low response rate may be that the principals initially contacted speciality S&T teachers only, which limited the number of participants drastically.

Based on the demographic information that has been gathered, it can be assumed that the sample population is rather homogeneous and that the small sample size of this study, therefore, allows some general predictions. Those predictions, however, are restricted to those people that fit into the category ‘elementary school teacher of South-Western Ontario’, meaning to people that are well educated and whose lives are constrained and limited by the geographical and social space they inhabit. It is assumed that the majority of participants are influenced by similar social constructs but no information concerning the participants’ cultural and social background has been collected. However, it appears that the sample used in this study is not representative in regards to their science and mathematics background. The fact that 70% of the respondents took grade 13 mathematics and that about 40% of the respondents took grade 13 biology, chemistry, and/or physics (see CHAPTER IV, p. 43), seems unusual since many elementary school teachers have a much lower educational background in those subjects.

Another restriction might be that a convenience sampling procedure was used for both the quantitative as well as the qualitative data collection, which means the sample may not be representative. Furthermore, the study participants might have been biased because they might have felt compelled to take part in this study since they have been more comfortable with, or more confident in, their S&T teaching than those that did not respond to the survey. This might be especially true for those who agreed on being interviewed after the survey since it is only human to avoid being asked about subjects one does not feel comfortable with or that might even be embarrassing in any way.

The use of an on-line questionnaire holds the danger that people other than the targeted population completed it. Another disadvantage of an on-line questionnaire could be the lack of opportunity for the researcher to provide direct assistance to participants for survey completion. This assumption can also be made in regards to the question about the high school courses taken by the participants. Participants that had a higher science background, meaning those who took more advanced science classes and/or for a longer period of time, answered probably more often than those who had a lower science background. One indication of this supposition could be that relatively more respondents failed to answer the question about physics courses taken than about biology or chemistry.

Further, although a relatively high percentage of respondents that answered the question concerning high school courses taken, completed for example grade 13 in mathematics (70%) and grade 13 in physics (43%), it can be assumed that the overall number of participants that completed the highest grade in these subjects is relatively low. The total number of participants that answered the questions about what science or mathematics courses they took in high school was 23 for mathematics (46% of all participants) and 21 for physics (42% of all participants). That means that seemingly a total of 16 participants only completed grade 13 in math and 9 participants completed grade 13 in physics. The number of participants that completed grade 13 in chemistry was 11 (37% of responses) and 13 (42%) in biology. Further, the fact that grade 13 was discontinued in Ontario and some other provinces in the year 2003 might have impacted the data.

The analysis of gender-related issues could have been more comprehensive if the number of male participants was higher. Research suggests, for instance, that gender-related differences occur among female teachers and male teachers (Eccles, 1987).

<u>Reliability of questionnaire</u>

The Cronbach's alpha for scale beliefs regarding scientists and S&T suggests that the scale is not internally consistent ($\alpha = 0.425$), which might be due to the fact that the questions in this scale inquire about three different aspects: teachers' beliefs regarding (a) S&T in general; (b) gender issues in S&T; and (c) scientists and engineers. Furthermore, some of the statements in this scale express generalizations and prejudices (for example: “The world would be a better place without S&T”), which might have resulted in some participants responding to the statements insincerely or not at all (response rate was with N=45 lower than for the other attribute scales). One subject commented on this scale by stating that “Questions I have not answered are value judgements that I am not prepared to make. They appear to be very stereotypical.”

Test-retest reliability could not be conducted due to time constrains and the low number of participants.

Because the data collected from the questionnaire allowed for good predictions in two multiple regression analyses as well as multiple confirmations of the quantitative results by qualitative means, it is assumed that the survey instrument is valid to predict teachers’ attitudes toward S&T teaching.

Researcher

Survey: To eliminate data collector bias or threats to testing, the surveys were scored and ranked by electronic means.

Interview: To reduce interviewer bias, the interviews were structured and the same set of questions was asked. However, the researcher went beyond the preset interview questions to clarify or to tease out certain issues, which might have manipulated the interview process.

Interviewee

It is possible that interviewees were biased because they completed the questionnaire before the interview. Also the gender of the researcher may have been an issue with some interviewees.

Discrepancies among quantitative data and qualitative data

The possibility exists that discrepancies between the quantitative and qualitative analyses occurred since the statements in the questionnaire that focused on a certain aspect were different from the questions asked in the interview concerning the same aspect. Further, some of the survey statements might not have been sufficiently detailed to allow for a direct comparison of the responses with the responses obtained during the interviews. This is particularly the case with respect to gender issues (students and scientists) but more detailed survey statements may lead to biased answers.

C. CONCLUSION

Teachers' attitudes toward the teaching of S&T are multifaceted and difficult to determine. A clear-cut position between positive and negative attitudes is almost impossible and depends on the criteria used to unravel this complex conception. The criteria used in this study were enjoyment of S&T teaching; expectations for students; work-related experiences; teachers' confidence and comfort level; teachers' knowledge gained in high school, university and otherwise; as well as teachers' beliefs and biases about gender issues in S&T. Each of these aspects is complex and interlinked, which makes it very difficult to investigate the concept of teacher's attitude in isolation. Moreover, a teacher might show a relatively positive attitude in one of the criteria but a relatively low attitude in another, depending on her/his beliefs, and teaching and learning experiences. Even more complicated is the examination of teachers' attitudes and perceptions in regards to gender since teachers, like everybody else, not only have their own suppositions that are more or less predetermined, but they are continually influenced by the divergent gender-related expectations society, school administration, parents, and students impose on them.

These gender-based expectations and other expectations are constantly present in the S&T classroom, which is why it is essential for a teacher to be aware of her/his own beliefs and preconceptions in order to prevent any stereotypical or gender-biased thinking from influencing her/his S&T teaching. As outlined in the discussion chapter, expectations and beliefs seem to influence teachers' attitudes toward S&T teaching in mainly two ways: directly via her/his own expectations and beliefs or indirectly by means of students' and society's expectations and beliefs. Therefore, it is assumed that teachers' attitudes toward S&T teaching are positively related to students' attitudes toward S&T learning and vice-versa.

The qualitative data confirmed some findings from the quantitative analysis and put others into perspective. The outcomes indicate that a solid science background increases S&T teachers' confidence and comfort level in S&T teaching, which is particularly the case when teaching the intermediate grades. It is further suggested that teachers with a BSc or advanced education in the sciences are not intimidated by science and, therefore, do not exhibit the level of science anxiety other S&T teachers without a BSc might have developed during childhood and adolescence.

Furthermore, although it is commonly assumed that a confident teacher who teaches within her/his area of specialization usually adopts a more positive attitude toward S&T teaching, this is not generally the case. This phenomenon can be explained by the fact that other variables such as teachers' age, self-esteem, experiences with students and their parents, as well as satisfaction in the job seemingly have a stronger impact on the formation of one's attitudes toward S&T teaching.

On the other hand, in some instances, an advanced science background seems to not be necessary for teachers to adopt a positive attitude to S&T if one has strong self-confidence and have had mainly positive learning experiences with students and their parents. It has also been found that the attitude toward S&T teaching of a very knowledgeable and competent S&T teacher may change from positive to negative if her/his expectations regarding students' attitudes toward S&T learning are not met. At the same time, a teacher with limited S&T knowledge and science apprehension, might learn with increasing expertise, and mostly positive experiences in the S&T classroom, to work around her/his anxiety by giving preference to topics and teaching units that they feel comfortable with. However, a teacher whose previous experiences with S&T were negative might never completely overcome her/his uneasiness that impacts her/his attitude to S&T teaching. Moreover, a teacher who is afraid of mathematics and physics and S&T subjects that are more challenging might avoid those subjects as much as possible or teach them with hesitation.

The findings further suggest that teachers who perceive students' overall learning attitude as positive are not aware of the different attitudes girls and boys may hold toward S&T learning. These teachers also believe that science is 'gender-neutral'(anybody can learn it); consequently, they hold a positive attitude toward S&T teaching.

The analyses of the data further indicate that teachers who believe that science is primarily conducted physically by working with the hands and using tools and instrumentation tend to emphasize a hands-on approach to S&T teaching. This is apparently more enjoyable to most teachers and students than theoretical tasks that involve reading and writing. Consequently, teachers and students who would prefer non-physical, academic work that is more based on abstract theoretical concepts may develop more negative attitudes toward S&T since this approach is seemingly not much supported by school administrators, parents, and students. The study findings also suggest that teachers who believe a 'proper' scientist is primarily male, objective, and rational apparently attain attitudes toward S&T teaching that are somewhat gender-biased. That means the attained attitude, which could be relatively positive or relatively negative, seemingly depends on the extent a teacher recognizes that the dominant knowledge practices of inquiry and justification are male-dominated and who subconsciously accepts the idea of science as a masculine concept.

A relatively negative attitude may be developed by teachers who are aware of the inequitable ways women in S&T are portrayed, who recognize gender inequalities in the workforce and, consequently, know how important it is for female students to excel in school. Moreover, those teachers may believe that female students have to perform better than male students in S&T in order to overcome existing obstacles on the way to becoming successful and independent professionals. On the other hand, a relatively positive attitude toward the teaching of S&T may be found in teachers who do not see a problem with the prevalent, rather masculine philosophy of science and who do not question the way science is done and how scientists are portrayed in the society. Therefore, it is hypothesized that teachers with an advanced science background, who are rather uncritical of the prevalent philosophy of science are more likely to have adopted an attitude to science that is more gender-biased since a primarily male-oriented disposition is dominant in most sciences.

The outcomes of the study suggest that S&T elementary school teachers in the South-Western Ontario region overwhelmingly fulfill what they perceive as their mandate. That is, they care for their students, strive to treat female and male students equally in their classes, teach S&T to their ability, and incorporate the recommended teaching approach in order to get young children interested in S&T. However, the hands-on approach, although seemingly effective for capturing the interest of the majority of grade 4 to 8 students, might not help all students alike in learning S&T. This approach apparently does not foster those students that prefer sedentary, theoretical work, which are mostly the students that constitute the minority in S&T classes, and who are predominantly female.

Some things in the way S&T is taught in elementary school have changed and others have not. It seems as if the grade 4 to 8 teachers in the South-Western Ontario region overwhelmingly enjoy teaching S&T. However, this study findings also suggest that the vast majority of these teachers are deficient in the subject-matter knowledge they need to comfortably teach S&T in the grades 6, 7, and 8, and partially in the lower grades, too. Moreover, a considerable number of grade 4 to 8 teachers seem to lack knowledge of the social and philosophical aspects of science and are not aware of their own beliefs and biases. Therefore, it is crucial that grade 4 to 8 teachers in the South-Western Ontario region are more encouraged to critically reflect on their S&T teaching and learn more about the non-scientific side of S&T, particularly concerning gender issues. This, however, is not possible without providing the resources, space and time to do so and to help and support teachers who are brave enough to swim against the mainstream beliefs about science and scientists.

D. IMPLICATION AND RECOMMENDATIONS

The findings of this study have implications for the Ontario education system, both school boards of the South-Western Ontario region, school administrators of the South-Western Ontario region, and education faculties of universities in the South-Western Ontario region. The study outcomes can be used to implement measures that could help elementary school teachers in the South-Western Ontario region to reduce their stress level caused by apprehension against science, to enhance their comfort level with S&T teaching, to increase their awareness of gender differences in students' S&T learning, and to facilitate self-reflection on their beliefs and biases concerning scientists and the nature of science. Moreover, the findings of this study revealed a need for further attitudinal studies on a much larger scale as well as research that explores in more detail the implications of the teaching strategies employed by grade 4 to 8 teachers.

Teaching strategies

This study provides information about the support and guidance grade 4 to 8 teachers who teach S&T need in order to fulfill their mandate concerning the learning opportunities for their students. This mandate, which is outlined in the Ontario Science and Technology Curriculum for grades 1 to 8 (Ontario Ministry of Education, 2007) includes the expectation that "teachers bring enthusiasm and varied teaching and assessment approaches to the classroom, addressing individual students' needs and ensuring sound learning opportunities for every student" (p. 8). The strategies suggested in the ministerial document under 'roles and responsibilities of teachers' focus on hands-on activities for students that are intended to facilitate the development and refinement of students' inquiry and problem-solving skills among other things "while discovering fundamental concepts through investigation, exploration, observation, and experimentation" (Ontario Ministry of Education, 2007, p. 8).

The qualitative findings of this study suggest that most grade 4 to 8 teachers in South-Western Ontario meet the curriculum requirements by focusing on hands-on activities. At the same time the results propose that some of the studied teachers may avoid activities that focus on more abstract, theoretical thinking by neglecting reading and writing tasks or by evaluating relevant work less than active participation. Details regarding the kind, frequency and extent of the activities carried out in the S&T classrooms are not known but the interview data propose that considerable strategy differences exist that apparently impact teachers' and students' attitudes toward S&T. While the activity-based strategies suggested by the Ontario Ministry of Education generally help students constructing an understanding of how the natural world works, enhance students' attitudes toward S&T learning (Ornstein, 2006), and increase students' achievement overall (Stohr-Hunt, 1996), these strategies might not sufficiently foster science literacy. To reach universal science literacy, which is one of the main objectives delineated in the S&T curriculum (Ontario Ministry of Education, 2007), reading and writing in the science classroom is indispensable. Although words in textbooks do not give meaning to concepts and, therefore, are not the way understanding is communicated, they may serve as examples of how to communicate understanding, or may confirm or contradict an understanding. Further, textbooks or similar written sources help develop science literacy by introducing terms and giving definition, which are important tools to consolidate knowledge. Reading can also broaden the horizon, can be a source of comparison of ideas during concept development, can provide illustrations of how ideas and concepts can be expressed, can stimulate discussions, analysis, and evaluation – all of which is crucial for becoming scientifically literate. Moreover, reading of texts in S&T is the best way to prepare students for a profession in the fields of S&T. According to Tenopir and King (2004), cited in Norris et al (2008), scientists and engineers, for whom time is generally extremely scarce, spend on average about one quarter of their overall working time reading, and award-winning scientists read even more than others. Further, scientists consider reading "as essential to their research and as the primary source of creative stimulation" (Norris et al, 2008, p. 766), cited in Tenopir and King (2004). Writing in science classes, particularly in the middle (and higher) grades, plays a vital role in moving science away from the paradigm of memorizing facts toward a deeper understanding of complex scientific concepts. This can be done in the form of writing to inform a specific audience about what a student has seen, thought, and read or to reflect upon what s/he as learned and, with that, deepen one's understanding. For the abovementioned reasons, the importance of science literacy, and with that reading and writing in the S&T grade 4 to 8 classroom, has to be more strongly reflected in the Ontario S&T curriculum.

Education policy makers will benefit from this study when they become aware of inequality issues in the S&T classroom. A consequence of the applied approach suggested by the Ministry along with the provision of ready-to-go science kits or similar teaching aids by school boards seems to be that most grade 4 to 8 teachers in the South-Western Ontario region use hands-on activities that work for them and supposedly for most students. The chosen activities, however, may not, or only partially, facilitate the learning of S&T in every student. That is, minority students or students that are quieter and therefore not as visible in the classroom might be disadvantaged by this approach. In order to give all students equal opportunities to understand scientific concepts, strategies have to be put forward by the Ontario Ministry of Education that meet the needs not only of highly active and kinaesthetic children but of students that are challenged or intimidated by hands-on activities. This study shows that some teachers are not aware of the problems and challenges possibly faced by, for instance, those students who prefer, and perform better, in theoretical, more sedentary assignments in comparison to students who prefer hands-on activities. Although no research could be found that compared the impact of hands-on activities on the learning outcomes of students with divergent activity preferences in the S&T classroom, comparative studies show that not all students benefit from hands-on opportunities to the same extent. Zady, Portes, and Dan Ochs (2002), for instance, found that high achievers in grade 7 take advantage of science activities in cooperative learning groups, while most low achievers take the opportunity to be off task during those activities. However, the science activities Zady et al (2002) observed included not only practical events such as experiments with controlled variables, dissections, or construction of models but also paper and pencil projects. No details about the kind, frequency and/or extent of each activity or the degree of participation of students of both groups in each activity were given. Therefore, no further conclusions can be drawn about differences in learning approach preferences of the student groups studied by Zady et al (2002) and, consequently, no specific recommendations can be given concerning teaching strategies that target low achievers.

The findings of this study have implications for science coordinators and administrators of the school boards and elementary schools of the South-Western Ontario region, as well as Faculties of Education in Ontario. The qualitative results suggest that some teachers, particularly those with, in comparison to most interviewees, relatively negative attitudes toward S&T teaching incorporate student-directed hands-on activities into their curriculum less frequently than teachers with more positive attitudes. Three main reasons for this outcome were reported by these teachers: problems with students, lack of resources, and insufficient preparation time. One way to help teachers, who have difficulties with students not understanding and/or following instructions, being disengaged, and being difficult to control, is to offer different pre-service science methodology courses and more professional development opportunities. These courses could increase grade 4 to 8 S&T teachers' repertoire of teaching strategies in order to enable them to choose activities that are encouraging and meaningful to students with different abilities and backgrounds. The emphasis here is put on meaningful activities since students of different socio-economic and/or cultural backgrounds, for example, may gain access to knowledge differently and probably need different metaphors and examples to be able to relate what is taught to their previous experiences. The importance for indigenous students to be able to relate new and old knowledge has been pointed out by Ezeife (2003), for instance, who suggested the incorporation of elements and aspects that reflect the cultural heritage and lived experiences of indigenous students into the teaching of science and mathematics. Another approach to assist teachers in improving their practices in order to enhance their attitudes to S&T as well as the language and literacy development of diverse students groups has been suggested by Lee, Deaktor, Enders, and Lambert (2008). This approach, which delivered satisfactory results in a three-year pilot study with grade 3 to 5 educators, promotes the provision of intervention programs that include workshops and instructional units incorporating hands-on activities as well as activities or strategies that foster reading and writing in the context of science instruction (Lee et al, 2008).

Another reason mentioned by some interviewees who had a relatively negative attitude toward S&T teaching for giving students little or no opportunity to do hands-on activities was insufficient materials and time in the teaching schedule for setting up and carrying out laboratory activities. Similarly, elementary school teachers in Australia reported that they avoid science activities that involve equipment since they do not have the time to organize equipment and set it up (Appleton, 2002). Therefore, it is recommended that grade 4 to 8 teachers will be provided with resources and time that is necessary for preparing meaningful science activities, as well as more support and guidance that helps them dealing with diverse students. Principals and school board administrators will be rewarded with more positive attitudes toward S&T in teachers and students and, consequently, increased performances of teachers and learners.

Grade 4 to 8 teachers will develop a more positive attitude toward S&T teaching if they are provided with a S&T curriculum, support materials, and professional development opportunities that allow them to be more flexible in their choices of S&T activities. With the appropriate support, teachers will be able to meet the needs and expectations of students of diverse backgrounds and abilities and, consequently, will be rewarded with engaged students that not only enjoy activities in the S&T classroom but actively engage in learning scientific concepts.

Knowledge

This study provides information about the importance of teachers' content knowledge and pedagogical knowledge for their confidence in and their attitude to S&T teaching. The quantitative findings suggest that grade 4 to 8 teachers with a bachelor's degree in science (BSc) are more confident in and comfortable with their S&T teaching than teachers without a BSc. The qualitative results further revealed that the confidence/comfort level of teachers without a BSc or other additional science background is restricted to the subjects and units they taught before, which is commonly below grade 7. In order to ensure that S&T in grade 7 and 8 is taught by confident and knowledgeable educators, administrators of the school boards and elementary schools in the studied region have to ensure that these grades are taught by teachers who are specialized in S&T teaching. That is, depending on the size of the school, at least one specialty teacher with a solid, meaning university level science content knowledge should be employed at each elementary school to teach the middle grades. Ideally, all teachers that teach S&T in grade 4 and higher should have a BSc or should have taken at least two courses in each of the sciences as well as one in both mathematics and statistics at the undergraduate level. Alternatively, it is suggested that teachers, who want to teach S&T at the medium level, have grade 12 biology, chemistry, physics and mathematics, at the very least. This is, because the qualitative data suggest that even teachers who had a high school background in sciences (grade 11 biology or higher, grade 10 chemistry or higher, grade 10 physics or higher) and mathematics (grade 11 or higher) that was stronger than what is currently required for acceptance into the general degree program, lack self-confidence in teaching S&T, particularly in grade 7 and 8. Another reason for increasing the requirements for science content knowledge is that even very experienced teachers (20 and 31 years of S&T teaching) lack confidence if they were asked to teach S&T in a grade higher than 6 or a subject they do not feel competent in, as could be seen at the qualitative findings of this study.

Based on this study, it is further recommended to make regular S&T workshops for all in-service elementary school teachers mandatory to enhance their content knowledge. This seems to be crucial, on the one hand, since some elementary school teachers are not aware of their shortcomings in S&T content knowledge, and, on the other hand, because a low level of content knowledge has a negative impact on teachers' pedagogical content knowledge and restrains their ability to make new ideas and understandings accessible to young students (Garbett, 2003). Further, elementary teachers should be given more opportunities to enhance their S&T pedagogical content knowledge by offering specific S&T workshops and courses. It has been shown, for instance, that science methodology courses that are hands-on and field-based can increase confidence in elementary school teachers (Jarrett, 1998). Additionally, elementary in-service and pre-service teachers' pedagogical content knowledge should be enhanced in areas most of them do not feel competent in, such as physics. In this, focus should be laid on a research-based inquiry approach since this teaching strategy seems to be more successful in helping teachers to develop the type of knowledge necessary to be able to teach a given topic in physics effectively (pedagogical content knowledge) than with an approach that is mainly descriptive (McDermott et al, 2006).

Awareness

The qualitative findings disclosed that not all grade 4 to 8 teachers are aware of the fact that their S&T teaching as well as their perceptions of students' S&T learning are partially guided by gender bias. The study interviews also revealed in most teachers a lack of awareness of their attitudes, beliefs, and biases concerning scientists and the nature of science. These outcomes have implications for university teachers in science education, curriculum developers, school administrators, principals, and teachers since it is crucial to foster awareness continuously and at all levels of teachers' training. In order to improve the extent of consciousness in elementary school educators, it is important to trigger and promote reflective thinking in pre-service as well as in-service teachers and to teach them how to nurture their own reflective thought process. Without constant reflection, teachers may not be aware that what they teach in the S&T classroom and how they teach it is biased. Their teaching might be influenced by beliefs and preconceptions that are either based on their personal experiences or on the beliefs and preconceptions of their teachers. Research showed that S&T methodology workshops that integrate equity issues can help grade 4 and 5 teachers to become aware of the impact their gender-role stereotypes has on their teaching (Kahle, Anderson, & Damajanovic, 1991). Those workshops can, according to Kahle et al (1991), also help elementary teachers to modify their attitudes in ways that enhance particularly girls' levels of confidence in doing S&T in general and in subjects such as physics girls are seemingly more apprehensive about than boys. To foster an interest in S&T in all students equally, it is important that grade 4 to 8 teachers become aware of their prejudices about scientists and their ideas concerning the nature of science. This could be done by giving elementary teachers the opportunity to experience authentic research in industrial or university science/engineering laboratories or by bringing scientists and engineers into the elementary classroom. Further, teacher development projects and undergraduate courses should incorporate the history of science and philosophy of science in order to give teachers the opportunity to improve their knowledge about scientists and the nature of science. This is particularly significant since some participants in this study did not see the necessity of deconstructing the myth that science is free of subjectivity and that it is performed by people that are gender-neutral, meaning that their work is not influenced by their gender-role. Moreover, “it is through history of science that students can become aware of the open nature of science and, more importantly of the open nature of methods by which one can do science” (Elkana, 2000, p. 35). Additionally, if administrators of both school boards and schools provide elementary teachers with time and opportunities to learn about and critically analyze the history and philosophy of science, they will be rewarded with staff that has a more accurate picture of the nature of science. This is important for several reasons; one being to help teachers and students to distinguish between things that are more scientific and those that are less scientific (Smith & Scharmann, 1999), which is a major step in the preparation of students for working in S&T.

It is further recommended that the Ontario Science and Technology Curriculum for grades 1 to 8 (Ontario Ministry of Education, 2007) explicitly addresses the requirement of teaching the social aspects of the nature of science by looking at the history and philosophy of science with a critical lens. The incorporation of gender issues and questions related to minority groups in the S&T curriculum is further recommended since this study revealed that stereotyping is still a major problem in S&T.

Attitude

The findings of the present study provide information about the complexity of grade 4 to 8 teachers' attitudes toward the teaching of S&T and the multitude of causes that impact their attitudes. Due to this complexity, it is recommended to assist grade 4 to 8 teachers as well as pre-service elementary teachers in their quest for satisfactory ways to teach S&T at all administrative and educational levels. Moreover, both pre-service and in-service elementary teachers need to be given the opportunity and the encouragement to seek the pedagogical content knowledge necessary to teach S&T with confidence over a long period of time. It is crucial to aim for long-term support since it has been shown that single workshops or basic university-level courses are not sufficient to bring about belief and attitude change in S&T teachers (Brown & Melear, 2006; Tilgner, 1990). Because attitude enhancement relies to a large extent on the improvement of forces outside of the control of the teacher, it is crucial that the administration and the community agree on the value of S&T for our society and communicated that to the teacher.

Suggestions for future research

Due to the small sample size used in the quantitative part of this study, it is suggested to conduct further research on this topic using a much larger sample size. With a larger sample size it would be possible to conduct a comparative study that allows the examination of gender differences in female and male teachers' attitudes. Based on the findings of this study, future research should point to three main directions. First, a quantitative study is required to determine elementary teachers' pedagogical content knowledge. Second, research is needed that investigates through direct observations the kind and frequency of activities carried out in the elementary S&T classroom as well as students' preferences of teaching/learning approaches. Third, research is needed that explores teachers' knowledge of the history of science, the philosophy of science, and the nature of science to unravel possible misconceptions about S&T. This is important in order to be able to correct these misconceptions and to align the theories of science teaching with the changes of both science and the philosophy of science in undergraduate education courses as well as teachers' development programs.

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APPENDICES

Appendix A

Survey instrument

I. BACKGROUND INFORMATION

In the first section I would like you to provide me with your demographic information.

(*Please fill in the information and place check mark where appropriate.*)

[Please note that the following information will be kept strictly confidential and that providing me with your personal data is voluntary.]

1. **Gender male ☐ female ☐ transgender ☐ inter-sex ☐**

2. **Age**

23 years and under	☐
24 to 30 years	☐
31 to 40 years	☐
41 to 50 years	☐
51 to 65 years	☐

3. **Educational background**

A. High School courses taken:
(*please circle all applicable numbers*)
1 Biology
(*please specify)* (a) Level/s________________(b) Years _________________
2 Chemistry
(*please specify)* (a) Level/s________________(b) Years _________________
3 Physics
(*please specify)* (a) Level/s________________(b) Years _________________
4 Mathematics
(*please specify)* (a) Level/s________________(b) Years _________________
5 Other
(*please specify)* (a) Level/s________________(b) Years _________________

B. University degrees obtained:
(*please circle applicable number/s*)
1 Bachelor in Education
2 Master in Education
3 Bachelor of Science
(if yes, *please specify*)
____
4 Master of Science
(if yes, *please specify, e.g. chemistry*) _______________________________
5 Other (*please, specify*) _______________________________

4. **Teaching experience**

(*please indicate number of years; if less than 2 years, please specify in months*)
Overall
____
Science & Technology _______________________________
Other
____

5. **Size of current science and technology class/es**
(*please indicate all class sizes if you teach more than one class this term; please use slashes to subdivide them; for example: 25 / 28*)
Number of students
____

6. **Grade(s) taught science and technology (*please indicate all grades*)**
This academic year
____
Last two academic years
____
Last three academic years
____
Last four academic years
____
Other (*please indicate what grades you have taught for how many years, if you have more than four years of teaching experience in science and technology*)
____

7. **Employment as teacher**
(*please indicate if full-time or part-time employed by circling applicable number*)
1 Full-time with current teaching load of at least 60%
2 Part-time with current teaching load of less than 60%

8. **Student population of School you are teaching at (*please check mark*)**

☐ **Less than 500**
☐ **Between 500 and 1000**
☐ **More than 1000**

9. **Type of School you are teaching at (*please check mark*)**

☐ **Urban school**
(urban area with a population greater than 100,000)
☐ **Rural school**
(urban area with a population smaller than 100,000)
☐ **Other**

10. Other working experiences (*please indicate*)

Area

____

Number of years

____

Comments:

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II. TEACHING OF SCIENCE AND TECHNOLOGY

In the second section, I would like you to indicate how you see yourself as a science and technology teacher.

(*Please rate how strongly you agree or disagree with each of the following statements by placing a check mark in the appropriate box.*)

		Strongly Disagree	Some-what Disagree	Neither Disagree nor Agree	Some-what Agree	Strongly Agree
1	I enjoy teaching science and technology					
2	I can tell that students understand what I explain in my science and technology class					
3	I am confident I can answer most of the students' questions					
4	I think I have adequate training to teach science and technology					
5	I consider myself a science and technology expert					
6	I integrate new scientific discoveries into my teaching					
7	I avoid using mathematics in my science and technology teaching					
8	Motivating students to participate in class activities is easy for me					
9	I enjoy discussing scientific and technological topics with colleagues					
10	Explaining a topic in different ways is difficult for me					

Comments:

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III. LEARNING OF SCIENCE AND TECHNOLOGY
In this section, I would like to ask you some questions about your own science and technology learning.

A. How informed do you feel about the following topics?

Please indicate by checking the appropriate boxes.

		Not informed at all	Vaguely informed	Well informed	Sufficiently informed to teach it	Informed enough to discuss it with experts
1	New Scientific Discoveries					
2	New Inventions and Technologies					
3	Space exploration					
4	Gene Technology					
5	Nanotechnology					
6	Global Warming					
7	New Medical Discoveries					
8	Environmental Issues					

Comments:

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B. What is your primary source of information in the area of science and technology?

Please rank the following items by using a scale from 1 to 10, where 1 is the source you use most and 10 the source you use the least:
(Please use each number only once.)

		Rank	Not Applicable
1	Internet	☐	☐
2	Books	☐	☐
3	Journals	☐	☐
4	Magazines	☐	☐
5	Television	☐	☐
6	Movies	☐	☐
7	Radio	☐	☐
8	Colleagues	☐	☐
9	Family and Friends	☐	☐
10	Experts	☐	☐

Comments:

C. Approximately, how often have you visited the following establishments within the last twelve months?

Please answer by checking the appropriate box below.					
		Never	Once or twice	Three to five times	Six or more times
1	Zoo				
2	Public Library				
3	Science and Technology Museum				
4	Art Gallery				
5	University or College Library				
6	Aquarium				
7	Sports Events				
8	Music Performances				
9	Botanical Garden				

Comments:

IV. STUDENTS' ATTITUDES TO SCIENCE & TECHNOLOGY **For the fourth section, I would like to get your opinion about students' attitudes toward science and technology.**

A. How would you describe students' attitudes toward science and technology?

Please rate how strongly you agree or disagree with each of the following statements by placing a check mark in the appropriate box.

		Strongly Disagree	Some-what Disagree	Neither Disagree nor Agree	Some-what Agree	Strongly Agree
1	Students are interested in topics covered in the science and technology class					
2	It is difficult to encourage children to study science and technology					
3	Students have difficulties understanding scientific concepts					
4	Students are scared of science and technology					
5	Students need a lot of extra help in science and technology					
6	Students enjoy discussing scientific problems in class					
7	Students have no difficulty with scientific thinking					
8	Students think science and technology is boring					

Comments:

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B. **When comparing the students in your science and technology class, would you say male and female students differ in the following categories?**

Please rate how strongly you agree or disagree with each of the following statements by placing a check mark in the appropriate box.						
	Female and male students	**Strongly Disagree**	**Some-what Disagree**	**Neither Disagree nor Agree**	**Some-what Agree**	**Strongly Agree**
1	**show the same amount of interest in science and technology**					
2	**are equally motivated to learn science and technology**					
3	**show the same degree of interest in hands-on-activities**					
4	**participate to the same extent in out-of-school science and technology activities**					
5	**devote about the same amount of time to studying science and technology**					
6	**need about the same amount of extra help**					
7	**have similar difficulties understanding scientific concepts**					

Comments:

V. PERCEPTIONS OF SCIENCE & TECHNOLOGY
For the fifth section, I would like you to provide your perceptions of real-world science and technology as well as scientists.

A. What attitudes would you consider are essential for meaningful work in science and technology?

Please rate how important each of the following habits of mind are by placing a check mark in the appropriate box.						
		Very important	Important	Moderately important	Of little importance	Unimportant
1	Commitment to accuracy					
2	Precision					
3	Imagination					
4	Respect for living things					
5	Respect for the environment					
6	Integrity in observation					
7	Experimentation					
8	Presenting and reporting					
9	Respect for evidence					
10	Creativity					

Comments:

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B. To what extent do you agree or disagree with the following statements regarding science and technology and the people who work in those areas?

Please rate how strongly you agree or disagree with each of the following statements by placing a check mark in the appropriate box.						
		Strongly Disagree	**Some-what Disagree**	**Neither Disagree nor Agree**	**Some-what Agree**	**Strongly Agree**
1	The world would be a better place without science and technology					
2	Men and women are equally suitable to become scientists and engineers					
3	New technological inventions pose too many risks for the environment					
4	Scientists and engineers do not socialize as much as people who work in non-scientific fields					
5	Women are as interested in science and technology as men					
6	Scientists and engineers are very knowledgeable in their fields					
7	Without modern scientific discoveries and technological inventions the human race would struggle more					
8	Scientists and engineers are introverted					
9	Scientists and engineers are more interested in research than in teaching					
10	Scientists and engineers are devoted to their work					

Comments:

C. Thinking about knowledge and skills, what would you say are the five most important things a scientist or engineer should know or be able to do?

Please write one subject in each line of the following priority list, with the most important one at the top (#1) and the least important one at the bottom (#5).
1.
2.
3.
4.
5.

Comments:

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D. If you were in the position to decide what five academic subjects besides reading and writing should be taught at an elementary school (grades 1 to 8), what subjects would you choose?

Please write one subject in each line of the following priority list, with the most important one at the top (#1) and the least important one at the bottom (#5).
1.
2.
3.
4.
5.

Comments:

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Are there any additional comments you would like to make that are not addressed in this questionnaire?

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If you agree to be interviewed, please write the password you chose to enter the survey –or a different password– record it, and send it to me (haaser@uwindsor.ca).

Password: ______________________

Thank you very much for participating!

Please click the submit button below to complete the survey.

Appendix B - Interview Questions (Q=Question)

In the survey, you were asked a couple of questions about how you perceive yourself as science and technology teacher. Now, I would like you to share with me your thoughts and feelings regarding your science and technology teaching.

Q: [1] In teaching science and technology, what would you say is most important to you?

Q: [2] How would you describe your science teaching?

Q: [3] Do you use any specific practices and strategies that you think are relevant in the way you teach science and technology?

Q: [4] How do you rate yourself in regards to your confidence and competence to teach science and technology, using a scale of 1 to 5? In the survey, you were also asked about how you perceive the students in your S&T class.

Q: [5] Could you offer your point of view about your students' attitudes toward and perceptions of science and technology?

Q: [6] In your opinion, why do you think students have these perceptions?

In the survey, you were asked about your opinion regarding gender differences in students' attitude to the learning of science and technology.

Q: [7] Have you encountered gender differences in your science and technology classroom and if so, in which way?

Q: [8] Do you think boys and girls differ in their attitudes to and perceptions of school science and technology? Why or why not?

Q: [9] Do you believe that boys' and girls' abilities to learn science and technology differ? Why or why not?

Q: [10] Research suggests that fewer female than male students believe that they are sufficiently skilled in science at the beginning of high school. Have you seen similar tendencies in your science and technology classes and if so, in what grades? Further, do you have an idea about why this might be the case?

Q: [11] Would you say that you treat boys and girls in your science and technology class equally? How do you know this?

In the survey, you were also asked some questions concerning your opinion about science and technology in general and scientists in particular.

Q: [12] Could you please share with me your perceptions of a scientist?

Q: [13] Do you think women who pursue a career in science, engineering or technology encounter more or other obstacles than men? Why and what are these obstacles?

Q: [14] Would you agree with the statement that women and men in those fields are treated equally? Why or why not?

Q: [15] Do you think most people have a stereotypical image of a scientist? If so, in which way?

Q: [16] Would you say that your perceptions of a scientist are biased? If so, in which way?

Q: [17] How do you prevent any stereotypical or biased thinking from influencing your science and technology teaching? Please explain.

Q: [18] Would you choose to teach science and technology if you had the choice or would you prefer to teach another subject?

Q: [19] Would you like to see more science specific workshops or PD courses offered for non-specialty elementary school teachers?

Q: [20] Is there anything else you would like to share with me or draw my attention to?

Appendix C
Letter of Permission to University of Windsor Research Ethics Board

Rita Haase
xxxxxxxxxxxxx
xxxxxxxxxxxxx

November 13, 2007

Research Ethics Coordinator
Office of the Research Ethics Board
303 Assumption University Building

Re: Approval of Research Project for Thesis

Dear Coordinator, dear Committee Member,

As a graduate student at the University of Windsor, Faculty of Education, I am requesting the Research Review Committee's permission to conduct a research study to satisfy the thesis requirements for a Master of Education degree.

The proposed study will investigate elementary school science teacher's attitudes toward science and the teaching of Science and Technology (S&T), teachers' perceptions and possible stereotypical images of a scientist, as well as their attitudes toward the students they teach, that is, their attitudes to gender issues in the science classroom. The results hopefully will help to enhance students' interest in S&T to increase the number of students, particularly female students, aiming for an education and career in related fields. Furthermore, the proposed study aims to help elementary school S&T teachers to become aware of their attitudes to science and S&T teaching along with possible inequities in their S&T classroom, which could improve male and female students' attitudes toward science.

Presently, there are no known risks, participation is voluntary, and subjects may withdraw from both stages of the study at any time. The first stage will be an anonymous on-line survey for which no consent is required but consent will be sought in the second stage, before the interviews take place and confidentiality will be ensured.

Please find enclosed the ethics application, which includes two consent forms and two information letters, a copy of the survey instrument (appendix A), a copy of the interview instrument (appendix B), a copy of the thesis petition that provides a description of the study and an outline of the procedures (appendix C), as well as copies of letters to the school boards (appendix D), the school board science coordinators (appendix E), and the prospective study participants (appendix F).

Thank you very much.
Yours sincerely,

Rita Haase, Ph.D., M.Ed. candidate
Enclosures

Appendix D

Letter of Permission to School Boards Research Review Committee

Rita Haase
xxxxxxxxxxxxx
xxxxxxxxxxxxx

XXXXX
XXXXX
XXXXX
December 12, 2007

Re: Request for Ethics Approval: Elementary School Teachers' Attitudes toward Science and the Teaching of Science and Technology

Dear XXXXX:

As a graduate student at the Faculty of Education from the University of Windsor, I am requesting permission to conduct a research study with grade four to eight school teachers from XXXXX School Board to satisfy the thesis requirements for a Master of Education degree.

Using an anonymous on-line survey, the proposed study will examine grade four to eight school science teachers' attitudes toward the teaching of science and technology. In subsequent one-on-one interviews with a small number of survey participants, I will further explore teachers' perceptions of a scientist, their understanding of boys' and girls' attitudes to and difficulties with science and technology learning, as well make interconnections between teachers' behaviour in the science classroom and the gender of the students they teach. The study instruments (appendix A & B) are attached for your perusal.

Elementary school teachers play a crucial role in regards to the attitude students adopt toward science and technology. Teachers that are confident in and enthusiastic about the subject they teach, propel student's motivation not only to achieve in that subject while in school but to become a life-long learner in that discipline. This is very important in science and technology since the numbers of students overall, and female students in particular, that chose science and technology related subjects in high school and continue their education to pursue a career in fields such as chemistry, physics, or engineering has been low in the last fifteen years. As a consequence, the number of science and technology graduates does not meet the demand of the economy; consequently, the economic industries as well as academia have raised concerns that the Canadian economy will slow down because of the lack of qualified scientists and engineers.

One of the main reasons that influence students' decision to major in science and technology related subjects is the attitude students adopt toward those subjects. It has been shown that most female students and quite a number of male students do not proceed further in science, technology and mathematics, which are crucial for understanding hard sciences and engineering, because they do not like the subjects and cannot identify with scientists or engineers, even if they achieve in those areas. Research suggests that this dislike, which girls express earlier and to a greater extent than boys, begins to have a negative impact in students' science and technology learning around grade six. Therefore, it is important to convey a positive view of science to elementary students and to motivate them to learn science and technology before they start to dislike it.

This study then may provide insight into grade four to eight science teachers' attitudes to science and the teaching of science and technology. Through self-appraisal and sharing information the teachers might experience a boost in their motivation to teach science and technology. They might also gain self-esteem and confidence as science and technology teachers and be encouraged to further develop their personal-professional knowledge. Furthermore, the study might motivate participants to become proactive career-long students of science and technology teaching. By reflecting on their teaching philosophy, the teachers might be able to enhance their understanding of why integrating teaching the nature of science in grade four to eight classrooms is important. Moreover, the participating teachers might be encouraged to seek social and professional support from peers, principals, and science experts, reflect on the expectancies they have of students, develop unbiased conceptions of how students of both genders see and understand science and technology and learn how being male/female offers advantages in working with boys/girls in the science and technology classroom.

Presently, there are no known risks to the study, participation is voluntary, and study participants may withdraw from the study at any time. Letters of information for the on-line survey will be posted at the University of Windsor's main survey Web site (http://www.uwindsor.ca/users/h/haase1/main.nsf, available after ethics approval), another letter of information as well as a consent form will be presented to those teachers who will agree to participate in the subsequent semi-structured interviews. Interviews will take place at public places away from school premises and will take between 45 minutes to one hour.

The Research Ethics Board of the University of Windsor has approved this study preliminary provided that the school boards approve my application (see attached pdf-document 'REB temporary approval'). A copy of the approved REB Ethics Application is also attached.

If you have any questions, please feel free to contact me by e-mail (XXXXX) or by phone either at home (XXXXX) or at the University of Windsor (XXXXX). If you wish, you can also contact my thesis supervisor Dr. Anthony N. Ezeife at XXXXX (e-mail: XXXXX).

Thank you very much for considering this request for ethics approval.

Yours sincerely,

Rita Haase, Ph.D., M.Ed. Candidate

Enclosures

Appendix E
Letter of Permission to School Principals

Dear XXXXX:

Superintendent XXXXX from your school board has granted approval for me to conduct research in the elementary schools of the XXXXX and suggested that I get in contact with you to seek your approval to conduct the study with teachers of your school and to help me recruiting grade four to eight teachers that currently teach science and technology or have taught this school subject in the last four years at your school.

Using an anonymous on-line survey, the proposed study, which satisfies the thesis requirements for a Master of Education degree at the Faculty of Education, will examine elementary teachers' attitudes toward the teaching of science and technology. In subsequent one-on-one interviews with a small number of survey participants, I will further explore teachers' perceptions of a scientist, their understanding of boys' and girls' attitudes to as well as difficulties with science and technology learning, and make interconnections between teachers' behaviour in the science classroom and the gender of the students they teach.

Elementary school teachers play a crucial role in regards to the attitudes students adopt toward science and technology. Teachers that are confident in and enthusiastic about the subject they teach, propel student's motivation not only to achieve in that subject while in school but to become a life-long learner in that discipline. This is very important in science and technology since the numbers of students overall, and female students in particular, that chose science and technology related subjects in high school and continue their education to pursue a career in fields such as chemistry, physics, or engineering has been low in the last fifteen years. As a consequence, the number of science and technology graduates does not meet the demand of the economy; consequently, the economic industries as well as academia have raised concerns that the Canadian economy will slow down because of the lack of qualified scientists and engineers.

One of the main reasons that influence students' decision to major in science and technology related subjects is the attitude students adopt toward those subjects. It has been shown that most female students and quite a number of male students do not proceed further in science, technology and mathematics, which are crucial for understanding hard sciences and engineering, because they do not like the subjects and cannot identify with scientists or engineers, even if they achieve in those areas. Research suggests that this dislike, which girls express earlier and to a greater extent than boys, begins to have a negative impact in students' science and technology learning around grade six. Therefore, it is important to convey a positive view of science to elementary students and to motivate them to learn science and technology before they start to dislike it.

This study then may provide insight into grade four to eight science teachers' attitudes to science and the teaching of science and technology. Through self-appraisal and sharing information the teachers might experience a boost in their motivation to teach science and technology. They might also gain self-esteem and confidence as science and technology teachers and be encouraged to further develop their personal-professional knowledge. Furthermore, the study might motivate participants to become proactive career-long students of science and technology teaching. By reflecting on their teaching philosophy, the teachers might be able to enhance their understanding of why integrating teaching the nature of science in grade four to eight classrooms is important. Moreover, the participating teachers might be encouraged to seek social and professional support from their colleagues, from you, as their principal, and from science experts, reflect on the expectancies they have of students, develop unbiased conceptions of how students of both genders see and understand science and technology, and learn how being male/female offers advantages in working with boys/girls in the science and technology classroom.

If you allow me to conduct the study with staff of your school, I would like to ask if you could forward the attached letters to all grade four to eight science and technology teachers of your school.

If you have any questions, please feel free to contact me by e-mail (XXXXX) or by phone either at home (XXXXX) or at the University of Windsor (XXXXX). If you wish, you can also contact my thesis supervisor Dr. Anthony N. Ezeife at XXXXX (e-mail: XXXXX).

Thank you very much for helping in this research endeavour.

Yours sincerely,

Rita Haase

Rita Haase, Ph.D., M.Ed. Candidate

Appendix F
Letter of Information to Grade 4 to 8 Teachers

Rita Haase
xxxxxxxxxxxxx
xxxxxxxxxxxxx

March 25, 2008

Dear Teacher:

I invite you to participate in a study that I conduct together with my supervisor Dr. Ezeife as part of my Master's in Education thesis at the University of Windsor. The study aims to examine elementary school teacher's attitudes toward science and the teaching and learning of science and technology by asking questions about their view of the scientific world, their perceptions of a scientist, and about their professional aspirations and expectations of students.

All schools of the Windsor XXXXX School Board participate in this research project, which has been approved by the Research Ethics Board of the University of Windsor and the Research Review Committee of your school board. It will be conducted in two phases. Phase I consists of an on-line survey and in Phase II one-on-one interviews will be conducted with those survey participants who have agreed to be interviewed.

The on-line questionnaire takes about 15 to 20 minutes to complete (approximately 40 questions). The survey can be saved before completion and you can return by re-entering the personal password you choose at the beginning of the survey. You also have the option of skipping questions or to withdraw your response. However, your data cannot be withdrawn or changed once you have hit the submit button. A letter of information that further explains the purpose of this study, the procedures, potential risks and benefits, as well as other related information regarding your rights as research participant can be found at the University of Windsor's survey website (http://www.uwindsor.ca/teachersattitudes). **All research participants that take part in the on-line survey will be entered in a draw and have the chance to win a $50 voucher from CHAPTERS**.

I have asked the principal of your school to help me distribute my survey to all teachers that are currently teaching or have previously taught science and technology at the junior-intermediate level and who would be willing to participate in this research study.

To go to the survey, please use the following URL: **http://www.uwindsor.ca/teachersattitudes**. You will be asked to enter a **UWinID**, which is **etats**, and a **Password**, which is **science**. If you wish to receive a hard copy of the questionnaire, please contact me via phone or e-mail or, to ensure anonymity, ask the principal of your school to do so and I will send the survey form to you or your school.

The subsequent interviews will be arranged individually and will take place a couple of weeks after the implementation of the on-line survey with those participants that choose to be interviewed by providing me with a code at the end of the survey. **A small token of appreciation will be given to all interviewees**.

All data received from survey respondents are anonymous and information obtained from interviewees will be held in strict confidence. Please note that your participation in this study is completely voluntary and that your feedback is greatly appreciated.

If you have any questions, please feel free to contact me by e-mail (XXXXX) or by phone either at home (XXXXX) or at the University of Windsor (XXXXX). If you wish, you can also contact my thesis supervisor Dr. Anthony N. Ezeife at XXXXX (e-mail: XXXXX), as well as the University of Windsor Research Ethics Board Coordinator at XXXXX or by e-mail XXXXX.

Thank you very much in advance for supporting this research endeavour.

Yours sincerely,

Rita Haase

Appendix G

Age (years) * gender Crosstabulation

			gender		
			female	male	Total
Age (years)	24-30	Count	11	1	12
		% within Age (years)	91.7%	8.3%	100.0%
		% within gender	29.7%	7.7%	24.0%
		% of Total	22.0%	2.0%	24.0%
	31-40	Count	13	7	20
		% within Age (years)	65.0%	35.0%	100.0%
		% within gender	35.1%	53.8%	40.0%
		% of Total	26.0%	14.0%	40.0%
	41-50	Count	7	4	11
		% within Age (years)	63.6%	36.4%	100.0%
		% within gender	18.9%	30.8%	22.0%
		% of Total	14.0%	8.0%	22.0%
	51-65	Count	6	1	7
		% within Age (years)	85.7%	14.3%	100.0%
		% within gender	16.2%	7.7%	14.0%
		% of Total	12.0%	2.0%	14.0%
	Total	Count	37	13	50
		% within Age (years)	74.0%	26.0%	100.0%
		% within gender	100.0%	100.0%	100.0%
		% of Total	74.0%	26.0%	100.0%

Appendix H - Pearson Correlation Analysis - Scale II (Attitude; reverse-scaled items included)

		enjoyment of teaching	confidence in student's understanding	confidence in answering questions	belief in adequate training	confidence in expertise	integration of new discoveries	avoidance of mathematics	confidence in motivating students	enjoyment of discussions with colleagues	difficulty in explaining in different ways
enjoyment of teaching	Pearson Corr.	1.000	.383**	.468**	.556**	.450**	.393**	.109	.229	.537**	.136
	Sig. (2-tailed)		.006	.001	.000	.001	.005	.453	.109	.000	.346
	N	50	50	50	50	50	50	50	50	50	50
confidence in student's understanding	Pearson Corr.	.383**	1.000	.631**	.470**	.368**	.354*	.216	.055	.329*	.317*
	Sig. (2-tailed)	.006		.000	.001	.009	.012	.132	.706	.020	.025
	N	50	50	50	50	50	50	50	50	50	50
confidence in answering questions	Pearson Corr.	.468**	.631**	1.000	.703**	.688**	.456**	.165	-.007	.294*	.201
	Sig. (2-tailed)	.001	.000		.000	.000	.001	.251	.963	.038	.161
	N	50	50	50	50	50	50	50	50	50	50
belief in adequate training	Pearson Corr.	.556**	.470**	.703**	1.000	.814**	.263	.210	.039	.292*	.127
	Sig. (2-tailed)	.000	.001	.000		.000	.065	.144	.789	.040	.380
	N	50	50	50	50	50	50	50	50	50	50
confidence in expertise	Pearson Corr.	.450**	.368**	.688**	.814**	1.000	.323*	.141	.055	.278	.159
	Sig. (2-tailed)	.001	.009	.000	.000		.022	.330	.706	.050	.271
	N	50	50	50	50	50	50	50	50	50	50
integration of new discoveries	Pearson Corr.	.393**	.354*	.456**	.263	.323*	1.000	.295*	.133	.508**	.251
	Sig. (2-tailed)	.005	.012	.001	.065	.022		.038	.356	.000	.078
	N	50	50	50	50	50	50	50	50	50	50
avoidance of mathematics	Pearson Corr.	.109	.216	.165	.210	.141	.295*	1.000	.226	.219	.304*
	Sig. (2-tailed)	.453	.132	.251	.144	.330	.038		.114	.126	.032
	N	50	50	50	50	50	50	50	50	50	50
confidence in motivating students	Pearson Corr.	.229	.055	-.007	.039	.055	.133	.226	1.000	.248	.328*
	Sig. (2-tailed)	.109	.706	.963	.789	.706	.356	.114		.082	.020
	N	50	50	50	50	50	50	50	50	50	50
enjoyment of discussions with colleagues	Pearson Corr.	.537**	.329*	.294*	.292*	.278	.508**	.219	.248	1.000	.146
	Sig. (2-tailed)	.000	.020	.038	.040	.050	.000	.126	.082		.311
	N	50	50	50	50	50	50	50	50	50	50
difficulty in explaining in different ways	Pearson Corr.	.136	.317*	.201	.127	.159	.251	.304*	.328*	.146	1.000
	Sig. (2-tailed)	.346	.025	.161	.380	.271	.078	.032	.020	.311	
	N	50	50	50	50	50	50	50	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix H - Pearson Correlation Analysis - Scale IVA (Perception of Students' Attitude; reverse-scaled items included)

		students show interest	students hard to encourage	students difficulty in understanding	students are scared	students need help	students enjoy discussions	students think scientifically	students are bored
students show interest	Pearson Correlation	1.000	-.314*	-.300*	-.507**	-.340*	.704**	.430**	-.541**
	Sig. (2-tailed)		.026	.034	.000	.016	.000	.002	.000
	N	50	50	50	50	50	50	50	50
students hard to encourage	Pearson Correlation	-.314*	1.000	.338*	.501**	.399**	-.218	-.378**	.443**
	Sig. (2-tailed)	.026		.016	.000	.004	.128	.007	.001
	N	50	50	50	50	50	50	50	50
students difficulty in understanding	Pearson Correlation	-.300*	.338*	1.000	.535**	.570**	-.442**	-.578**	.414**
	Sig. (2-tailed)	.034	.016		.000	.000	.001	.000	.003
	N	50	50	50	50	50	50	50	50
students are scared	Pearson Correlation	-.507**	.501**	.535**	1.000	.447**	-.325*	-.336*	.431**
	Sig. (2-tailed)	.000	.000	.000		.001	.021	.017	.002
	N	50	50	50	50	50	50	50	50
students need help	Pearson Correlation	-.340*	.399**	.570**	.447**	1.000	-.404**	-.569**	.436**
	Sig. (2-tailed)	.016	.004	.000	.001		.004	.000	.002
	N	50	50	50	50	50	50	50	50
students enjoy discussions	Pearson Correlation	.704**	-.218	-.442**	-.325*	-.404**	1.000	.509**	-.493**
	Sig. (2-tailed)	.000	.128	.001	.021	.004		.000	.000
	N	50	50	50	50	50	50	50	50
students think scientifically	Pearson Correlation	.430**	-.378**	-.578**	-.336*	-.569**	.509**	1.000	-.517**
	Sig. (2-tailed)	.002	.007	.000	.017	.000	.000		.000
	N	50	50	50	50	50	50	50	50
students are bored	Pearson Correlation	-.541**	.443**	.414**	.431**	.436**	-.493**	-.517**	1.000
	Sig. (2-tailed)	.000	.001	.003	.002	.002	.000	.000	
	N	50	50	50	50	50	50	50	50

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix H - Pearson Correlation Analyses - Scale IVB (Perception of Gender Differences in Students' Attitudes)

		gender differences - interest	gender differences - motivation	gender differences - hands-on	gender differences - outdoor activities	gender differences - study duration	gender differences - extra help	gender differences - understanding scientific concepts
gender differences - interest	Pearson Correlation	1.000	.858**	.770**	.512**	.341*	.350*	.281*
	Sig. (2-tailed)		.000	.000	.000	.015	.013	.048
	N	50	50	50	50	50	50	50
gender differences - motivation	Pearson Correlation	.858**	1.000	.668**	.578**	.415**	.346*	.330*
	Sig. (2-tailed)	.000		.000	.000	.003	.014	.019
	N	50	50	50	50	50	50	50
gender differences - hands-on	Pearson Correlation	.770**	.668**	1.000	.430**	.385**	.281*	.231
	Sig. (2-tailed)	.000	.000		.002	.006	.048	.106
	N	50	50	50	50	50	50	50
gender differences - outdoor activities	Pearson Correlation	.512**	.578**	.430**	1.000	.381**	.374**	.502**
	Sig. (2-tailed)	.000	.000	.002		.006	.007	.000
	N	50	50	50	50	50	50	50
gender differences - study duration	Pearson Correlation	.341*	.415**	.385**	.381**	1.000	.655**	.277
	Sig. (2-tailed)	.015	.003	.006	.006		.000	.051
	N	50	50	50	50	50	50	50
gender differences - extra help	Pearson Correlation	.350*	.346*	.281*	.374**	.655**	1.000	.516**
	Sig. (2-tailed)	.013	.014	.048	.007	.000		.000
	N	50	50	50	50	50	50	50
gender differences - understanding scientific concepts	Pearson Correlation	.281*	.330*	.231	.502**	.277	.516**	1.000
	Sig. (2-tailed)	.048	.019	.106	.000	.051	.000	
	N	50	50	50	50	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix H - Pearson Correlation Analysis - Scale VA (Perception of Scientific Approach; reverse-scaled items included)

		perception scientist - accuracy	perception scientist - precision	perception scientist - imagination	perc. scientist - respect living things	perc. scientist - respect environment	perc. scientist - integrity in observation	perception scientist - experimentation	perception scientist - presentation	perc. scientist - respect evidence	perception scientist - creativity
perception scientist - accuracy	Pearson Corr.	1.000	.909**	.635**	.540**	.498**	.712**	.225	.137	.741**	.131
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.129	.359	.000	.381
	N	47	47	47	47	47	47	47	47	47	47
perception scientist - precision	Pearson Corr.	.909**	1.000	.659**	.539**	.468**	.700**	.211	.169	.696**	.163
	Sig. (2-tailed)	.000		.000	.000	.001	.000	.154	.257	.000	.272
	N	47	47	47	47	47	47	47	47	47	47
perception scientist - imagination	Pearson Corr.	.635**	.659**	1.000	.681**	.695**	.714**	.309*	.173	.679**	.510**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.034	.245	.000	.000
	N	47	47	47	47	47	47	47	47	47	47
perception scientist - respect living things	Pearson Corr.	.540**	.539**	.681**	1.000	.951**	.633**	.110	.176	.630**	.224
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.463	.237	.000	.130
	N	47	47	47	47	47	47	47	47	47	47
perception scientist - respect environment	Pearson Corr.	.498**	.468**	.695**	.951**	1.000	.611**	.120	.187	.644**	.208
	Sig. (2-tailed)	.000	.001	.000	.000		.000	.423	.209	.000	.161
	N	47	47	47	47	47	47	47	47	47	47
perception scientist - integrity in observation	Pearson Corr.	.712**	.700**	.714**	.633**	.611**	1.000	.342*	.272	.732**	.141
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.019	.064	.000	.345
	N	47	47	47	47	47	47	47	47	47	47
perception scientist - experimentation	Pearson Corr.	.225	.211	.309*	.110	.120	.342*	1.000	.551**	.457**	.533**
	Sig. (2-tailed)	.129	.154	.034	.463	.423	.019		.000	.001	.000
	N	47	47	47	47	47	47	47	47	47	47
perception scientist - presentation	Pearson Corr.	.137	.169	.173	.176	.187	.272	.551**	1.000	.354*	.447**
	Sig. (2-tailed)	.359	.257	.245	.237	.209	.064	.000		.015	.002
	N	47	47	47	47	47	47	47	47	47	47
perception scientist - respect evidence	Pearson Corr.	.741**	.696**	.679**	.630**	.644**	.732**	.457**	.354*	1.000	.270
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.001	.015		.066
	N	47	47	47	47	47	47	47	47	47	47
perception scientist - creativity	Pearson Corr.	.131	.163	.510**	.224	.208	.141	.533**	.447**	.270	1.000
	Sig. (2-tailed)	.381	.272	.000	.130	.161	.345	.000	.002	.066	
	N	47	47	47	47	47	47	47	47	47	47

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix H - Pearson Correlation Analysis - Scale VB (Beliefs about Scientists and S&T; reverse-scaled items included)

		gender equality scientists	belief science interest is gender neutral	perception scientists are knowledgeable	attitude to science and technology	scientists mainly researcher	scientists are devoted to work	perception - real world science	perception technol. - environment	perception of scientists - asocial	perception of scientists - introverted
gender equality scientists	Pearson Corr.	1.000	.153	-.180	-.209	-.248	.026	-.043	-.006	-.142	.094
	Sig. (2-tailed)		.306	.227	.158	.097	.863	.777	.968	.347	.532
	N	47	47	47	47	46	46	46	47	46	46
belief science interest is gender neutral	Pearson Corr.	.153	1.000	.376**	.054	-.248	.234	.189	-.082	.179	.396**
	Sig. (2-tailed)	.306		.009	.716	.096	.118	.208	.583	.235	.006
	N	47	47	47	47	46	46	46	47	46	46
perception scientists are knowledgeable	Pearson Corr.	-.180	.376**	1.000	.183	.055	.532**	-.119	-.002	.191	.162
	Sig. (2-tailed)	.227	.009		.219	.717	.000	.432	.990	.204	.282
	N	47	47	47	47	46	46	46	47	46	46
attitude to science and technology	Pearson Corr.	-.209	.054	.183	1.000	.251	.384**	.021	.265	.146	-.079
	Sig. (2-tailed)	.158	.716	.219		.093	.009	.890	.072	.334	.603
	N	47	47	47	47	46	46	46	47	46	46
scientists mainly researcher	Pearson Corr.	-.248	-.248	.055	.251	1.000	.088	-.180	-.097	-.210	-.358*
	Sig. (2-tailed)	.097	.096	.717	.093		.560	.238	.522	.162	.015
	N	46	46	46	46	46	46	45	46	46	46
scientists are devoted to work	Pearson Corr.	.026	.234	.532**	.384**	.088	1.000	-.188	.353*	.253	.066
	Sig. (2-tailed)	.863	.118	.000	.009	.560		.215	.016	.090	.665
	N	46	46	46	46	46	46	45	46	46	46
perception - real world science	Pearson Corr.	-.043	.189	-.119	.021	-.180	-.188	1.000	-.089	-.194	-.167
	Sig. (2-tailed)	.777	.208	.432	.890	.238	.215		.558	.202	.274
	N	46	46	46	46	45	45	46	46	45	45
perception of new technol. - environment	Pearson Corr.	-.006	-.082	-.002	.265	-.097	.353*	-.089	1.000	.251	-.111
	Sig. (2-tailed)	.968	.583	.990	.072	.522	.016	.558		.093	.462
	N	47	47	47	47	46	46	46	47	46	46
perception of scientists - asocial	Pearson Corr.	-.142	.179	.191	.146	-.210	.253	-.194	.251	1.000	.689**
	Sig. (2-tailed)	.347	.235	.204	.334	.162	.090	.202	.093		.000
	N	46	46	46	46	46	46	45	46	46	46
perception of scientists - introverted	Pearson Corr.	.094	.396**	.162	-.079	-.358*	.066	-.167	-.111	.689**	1.000
	Sig. (2-tailed)	.532	.006	.282	.603	.015	.665	.274	.462	.000	
	N	46	46	46	46	46	46	45	46	46	46

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

VITA AUCTORIS

Rita Haase was born in Stukenbrock, Germany, in 1959. She studied Chemical Laboratory Technology at Dr. Blindow School of Chemistry (Bückeburg, Germany) from 1974 to 1976. Afterwards, she graduated from Hermann-Böse High school (Germany) in 1984. From there she went on to the University of Bremen (Germany) where she obtained a M.Sc. in Biology in 1990 and a Ph.D. in Marine Biology in 1995. Presently she works as a Sessional Instructor in the Women's Studies program at the University of Windsor, Ontario (Canada). She is currently completing her Master's degree in Education at the University of Windsor.